nature climate change

SUPPLEMENTARY INFORMATION

https://doi.org/10.1038/s41558-020-0847-4

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Global hunger and climate change adaptation through international trade

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Supplementary Information

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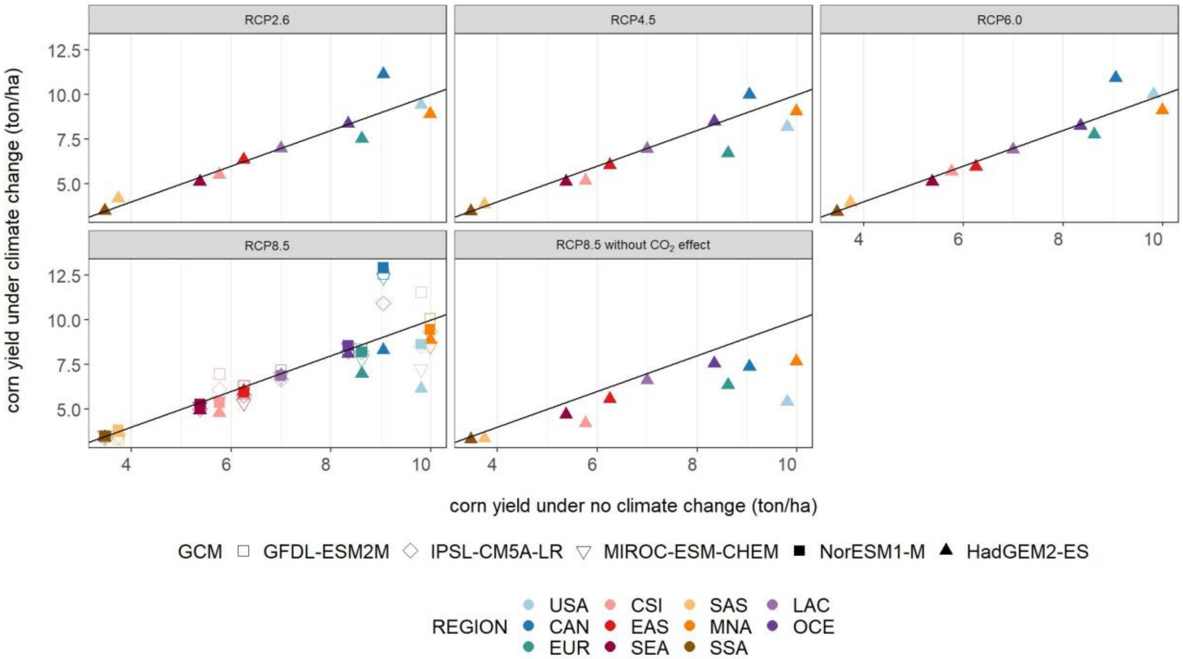
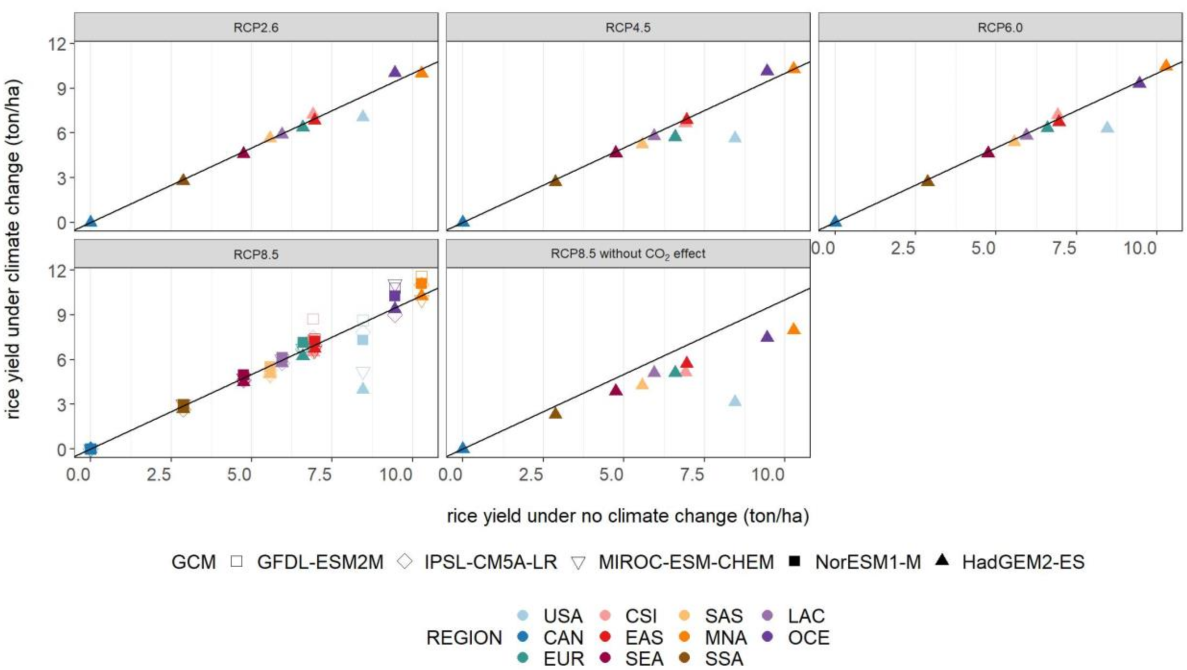
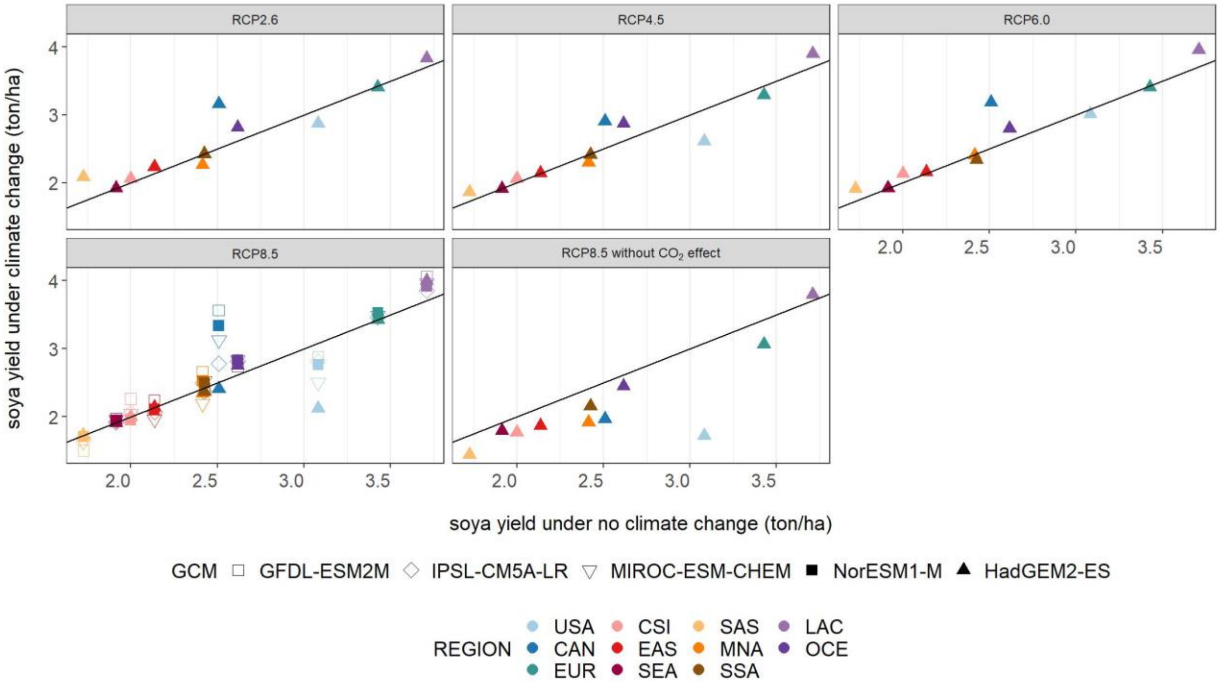


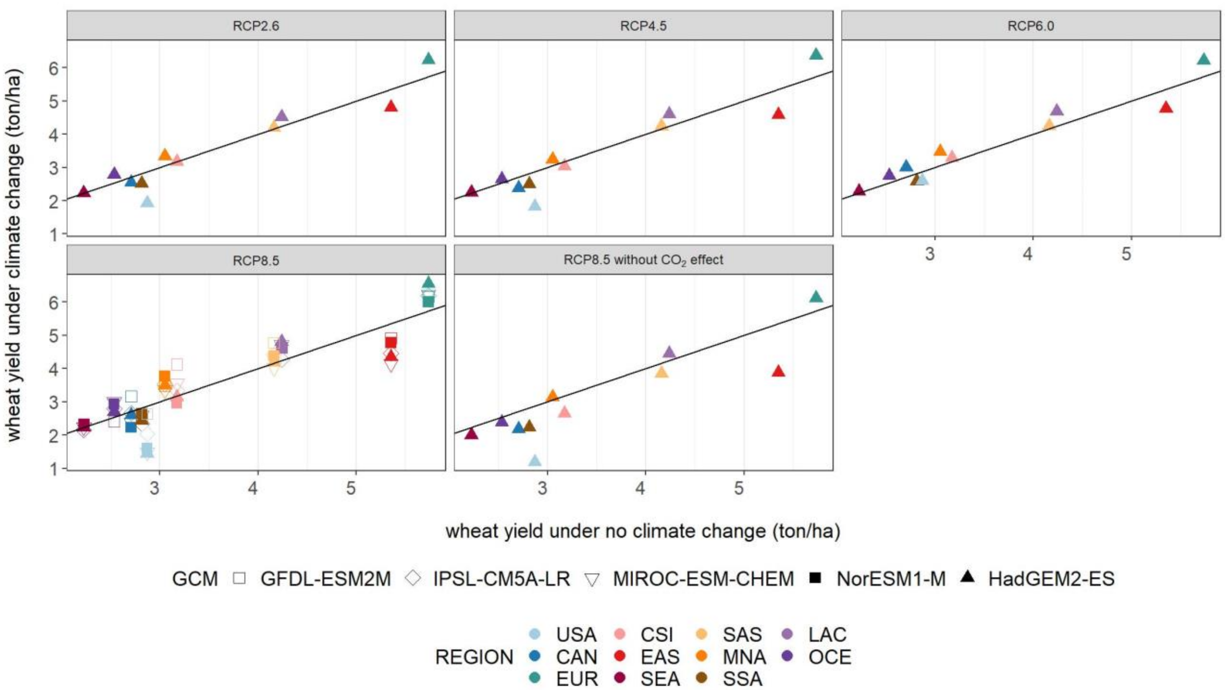
Supplementary Fig. 1 | Corn yield under climate change and under no climate change in each region by 2050 projected by the EPIC crop model. Yields in ton dry matter per ha. Under no climate change yields are determined by base year yields and assumptions on technological development over time, under climate change an additional climate impact shifter is applied.



Supplementary Fig. 2 | Rice yield under climate change and no climate change in each region by 2050 projected by the EPIC crop model. Yields in ton dry matter per ha. Under no climate change yields are determined by base year yield and assumptions on technological development over time, under climate change an additional climate impact shifter is applied.



Supplementary Fig. 3 | Soya yield under climate change and no climate change in each region by 2050 projected by the EPIC crop model. Yields in ton dry matter per ha. Under no climate change yields are determined by base year yield and assumptions on technological development over time, under climate change an additional climate impact shifter is applied.



Supplementary Fig. 4 | Wheat yield under climate change and no climate change in each region by 2050 projected by the EPIC crop model. Yields in ton dry matter per ha. Under no climate change yields are determined by base year yield and assumptions on technological development over time, under climate change an additional climate impact shifter is applied.

Supplementary Tables

Supplementary Table 1 | Global agricultural trade adjustments under trade and climate change scenarios by 2050. Total trade growth and specific extensive margin trade growth, the latter indicated as new trade flows compared to the 2000 trade pattern, the baseline SSP2 trade pattern, or the No CC trade pattern. RCP: Representative Concentration Pathway, GCM: General Circulation Model. Climate change scenarios include the effect of CO_2 fertilization on crop yields. RCP8.5 is also implemented without the CO_2 effect (RCP8.5 wo).

RCP	GCM	Trade scenario	Trade adjustments: Total agricultural trade volume (1000 ton)	Total volume of new trade flows w.r.t. 2000 (1000 ton)	Total volume of new trade flows w.r.t. SSP2 baseline (1000 ton)	Total volume of new trade flows w.r.t. No CC (1000 ton)
SPP2 Baseline						
No CC	None	Baseline	2 231 882	34 485	0	0
Trade and Climate Change scenarios						
RCP2.6	HadGEM2-ES	Baseline	2 279 118	36 859	27 603	27 603
RCP4.5	HadGEM2-ES	Baseline	2 296 414	38 420	27 019	27 019
RCP6.0	HadGEM2-ES	Baseline	2 331 759	37 971	36 719	36 719
RCP8.5	GFDL-ESM2M	Baseline	2 392 550	35 078	72 927	72 927
RCP8.5	HadGEM2-ES	Baseline	2 312 236	40 476	39 203	39 203
RCP8.5	IPSL-CM5A-LR	Baseline	2 310 881	38 543	35 854	35 854
RCP8.5	MIROC	Baseline	2 348 640	36 387	38 593	38 593
RCP8.5	NorESM1-M	Baseline	2 258 274	36 500	24 813	24 813
RCP8.5 wo	HadGEM2-ES	Baseline	2 296 093	44 733	53 881	53 881
No CC	None	Fixed imports	2 231 726	34 475	0	0
RCP2.6	HadGEM2-ES	Fixed imports	1 997 757	32 063	0	0
RCP4.5	HadGEM2-ES	Fixed imports	1 993 885	32 095	0	0
RCP6.0	HadGEM2-ES	Fixed imports	2 002 783	31 817	0	0
RCP8.5	GFDL-ESM2M	Fixed imports	2 081 805	31 172	0	0
RCP8.5	HadGEM2-ES	Fixed imports	1 896 043	31 165	0	0
RCP8.5	IPSL-CM5A-LR	Fixed imports	1 983 152	30 977	0	0
RCP8.5	MIROC	Fixed imports	1 950 371	30 541	0	0
RCP8.5	NorESM1-M	Fixed imports	2 021 484	31 656	0	0
RCP8.5 wo	HadGEM2-ES	Fixed imports	1 814 691	31 475	0	0
No CC	None	Pre-Doha tariffs	1 046 349	27 493	194 246	0
RCP2.6	HadGEM2-ES	Pre-Doha tariffs	1 137 845	30 149	206 727	70 453
RCP4.5	HadGEM2-ES	Pre-Doha tariffs	1 153 749	31 735	200 281	75 508
RCP6.0	HadGEM2-ES	Pre-Doha tariffs	1 158 766	31 224	212 409	72 076
RCP8.5	GFDL-ESM2M	Pre-Doha tariffs	1 190 440	28 164	243 935	57 923
RCP8.5	HadGEM2-ES	Pre-Doha tariffs	1 205 015	34 072	208 108	99 349
RCP8.5	IPSL-CM5A-LR	Pre-Doha tariffs	1 172 956	31 732	209 515	67 207
RCP8.5	MIROC	Pre-Doha tariffs	1 229 682	28 918	221 895	97 333
RCP8.5	NorESM1-M	Pre-Doha tariffs	1 108 162	29 159	197 632	65 287
RCP8.5 wo	HadGEM2-ES	Pre-Doha tariffs	1 272 373	38 217	232 223	133 426

Supplementary Table 1 *continued.*

RCP	GCM	Trade scenario	Trade adjustments: Total trade agricultural volume (1000 ton)	Total volume of new trade flows w.r.t. 2000 (1000 ton)	Total volume of new trade flows w.r.t. SSP2 baseline (1000 ton)	Total volume of new trade flows w.r.t. No CC (1000 ton)
No CC	None	Facilitation	4 808 943	45 157	126 711	0
RCP2.6	HadGEM2-ES	Facilitation	4 700 270	47 367	143 739	162 972
RCP4.5	HadGEM2-ES	Facilitation	4 637 072	50 034	157 980	180 892
RCP6.0	HadGEM2-ES	Facilitation	4 731 794	49 026	147 581	210 790
RCP8.5	GFDL-ESM2M	Facilitation	4 932 717	47 846	161 146	133 028
RCP8.5	HadGEM2-ES	Facilitation	4 375 589	52 343	171 053	361 853
RCP8.5	IPSL-CM5A-LR	Facilitation	4 618 677	50 190	163 629	132 825
RCP8.5	MIROC	Facilitation	4 710 517	49 657	195 841	223 134
RCP8.5	NorESM1-M	Facilitation	4 750 893	50 412	172 771	105 570
RCP8.5 wo	HadGEM2-ES	Facilitation	4 035 029	54 202	187 829	384 270
No CC	None	Tariff elimination	3 790 254	67 245	657 770	0
RCP2.6	HadGEM2-ES	Tariff elimination	3 879 544	67 863	715 503	33 870
RCP4.5	HadGEM2-ES	Tariff elimination	3 873 057	69 490	674 132	25 098
RCP6.0	HadGEM2-ES	Tariff elimination	3 975 979	68 151	721 417	34 852
RCP8.5	GFDL-ESM2M	Tariff elimination	3 987 976	64 978	770 460	52 951
RCP8.5	HadGEM2-ES	Tariff elimination	3 793 240	70 838	672 491	41 509
RCP8.5	IPSL-CM5A-LR	Tariff elimination	3 840 614	67 378	681 601	45 064
RCP8.5	MIROC	Tariff elimination	3 915 428	65 089	737 766	45 928
RCP8.5	NorESM1-M	Tariff elimination	3 849 080	65 463	699 887	21 403
RCP8.5 wo	HadGEM2-ES	Tariff elimination	3 592 066	77 612	643 519	47 724
No CC	None	Facilitation + Tariff	7 376 216	120 597	2 271 954	0
RCP2.6	HadGEM2-ES	Facilitation + Tariff	7 274 863	118 722	2 258 514	138 416
RCP4.5	HadGEM2-ES	Facilitation + Tariff	7 041 356	119 501	2 039 335	176 055
RCP6.0	HadGEM2-ES	Facilitation + Tariff	7 559 279	118 072	2 361 007	73 203
RCP8.5	GFDL-ESM2M	Facilitation + Tariff	8 077 702	116 314	2 718 236	95 738
RCP8.5	HadGEM2-ES	Facilitation + Tariff	6 576 789	118 638	2 066 236	195 542
RCP8.5	IPSL-CM5A-LR	Facilitation + Tariff	7 089 250	120 332	2 079 449	124 048
RCP8.5	MIROC	Facilitation + Tariff	7 115 186	114 886	2 275 812	143 824
RCP8.5	NorESM1-M	Facilitation + Tariff	7 424 135	120 259	2 290 354	74 486
RCP8.5 wo	HadGEM2-ES	Facilitation + Tariff	5 937 251	119 122	1 745 582	303 873

GCM MIROC: MIROC-ESM-CHEM

Supplementary Table 2 | Global market responses to trade scenarios compared to the *Baseline trade* scenario by 2050 under the different climate change scenarios. RCP: Representative Concentration Pathway, GCM: General Circulation Model. Climate change scenarios include the effect of CO_2 fertilization on crop yields. RCP8.5 is also implemented without the CO_2 effect (RCP8.5 wo). Global crop production efficiency is defined as the total global crop production over the total global cropland area.

			Market responses			
RCP	GCM	Trade scenario	Global crop production efficiency, difference to *Baseline trade* (%)	Global crop calorie production, difference to *Baseline trade* (%)	Global food availability , difference to *Baseline Trade* (kcal/cap/day)	Agricultural prices, difference compared to *Baseline trade* (%)
No CC	None	Fixed imports	0.00%	0.00%	0.00	0.09%
RCP2.6	HadGEM2-ES	Fixed imports	-1.87%	-1.92%	-14.24	1.90%
RCP4.5	HadGEM2-ES	Fixed imports	-1.87%	-2.06%	-11.70	2.36%
RCP6.0	HadGEM2-ES	Fixed imports	-1.56%	-2.18%	-14.39	2.16%
RCP8.5	GFDL-ESM2M	Fixed imports	-1.97%	-2.40%	-16.41	2.18%
RCP8.5	IPSL-CM5A-LR	Fixed imports	-1.56%	-2.24%	-18.13	3.08%
RCP8.5	MIROC	Fixed imports	-2.22%	-2.77%	-16.70	16.68%
RCP8.5	NorESM1-M	Fixed imports	-1.05%	-1.48%	-9.53	1.72%
RCP8.5	HadGEM2-ES	Fixed imports	-2.24%	-2.35%	-19.52	3.42%
RCP8.5 wo	HadGEM2-ES	Fixed imports	-2.45%	-2.67%	-36.85	8.58%
No CC	None	Pre-Doha tariffs	-2.63%	-4.19%	-50.43	5.13%
RCP2.6	HadGEM2-ES	Pre-Doha tariffs	-2.37%	-3.51%	-41.43	4.39%
RCP4.5	HadGEM2-ES	Pre-Doha tariffs	-1.89%	-3.23%	-41.76	4.17%
RCP6.0	HadGEM2-ES	Pre-Doha tariffs	-2.07%	-3.62%	-45.85	4.47%
RCP8.5	GFDL-ESM2M	Pre-Doha tariffs	-2.74%	-4.20%	-44.35	4.74%
RCP8.5	IPSL-CM5A-LR	Pre-Doha tariffs	-1.65%	-3.08%	-41.95	4.16%
RCP8.5	MIROC	Pre-Doha tariffs	-2.07%	-3.39%	-46.69	4.43%
RCP8.5	NorESM1-M	Pre-Doha tariffs	-1.86%	-3.30%	-42.92	4.24%
RCP8.5	HadGEM2-ES	Pre-Doha tariffs	-1.61%	-2.62%	-42.45	4.24%
RCP8.5 wo	HadGEM2-ES	Pre-Doha tariffs	-1.51%	-2.19%	-39.44	4.41%
No CC	None	Facilitation	2.66%	1.49%	31.65	-3.23%
RCP2.6	HadGEM2-ES	Facilitation	2.29%	1.53%	35.35	-3.40%
RCP4.5	HadGEM2-ES	Facilitation	1.55%	1.12%	35.96	-3.51%
RCP6.0	HadGEM2-ES	Facilitation	3.11%	2.48%	35.34	-3.81%
RCP8.5	GFDL-ESM2M	Facilitation	3.11%	2.10%	33.37	-3.85%
RCP8.5	IPSL-CM5A-LR	Facilitation	1.93%	1.46%	28.09	-3.64%
RCP8.5	MIROC	Facilitation	1.06%	0.55%	33.89	-3.41%
RCP8.5	NorESM1-M	Facilitation	1.82%	1.19%	35.42	-3.46%
RCP8.5	HadGEM2-ES	Facilitation	1.63%	1.34%	32.48	-3.84%
RCP8.5 wo	HadGEM2-ES	Facilitation	1.62%	1.19%	25.35	-3.45%

Supplementary Table 2 *continued.*

RCP	GCM	Trade scenario	Market responses Global production efficiency, difference to *Baseline trade* (%)	Global crop calorie production, difference to *Baseline trade* (%)	Global food availability , difference to *Baseline trade* (kcal/cap/day)	Agricultural prices, difference compared to *Baseline trade* (%)
No CC	None	Tariff elimination	2.34%	1.86%	29.29	-3.59%
RCP2.6	HadGEM2-ES	Tariff elimination	1.78%	1.52%	27.94	-3.55%
RCP4.5	HadGEM2-ES	Tariff elimination	1.85%	1.58%	28.78	-3.60%
RCP6.0	HadGEM2-ES	Tariff elimination	2.29%	2.01%	30.56	-3.74%
RCP8.5	GFDL-ESM2M	Tariff elimination	1.70%	1.23%	23.31	-3.22%
RCP8.5	IPSL-CM5A-LR	Tariff elimination	1.90%	1.72%	29.23	-3.53%
RCP8.5	MIROC	Tariff elimination	1.92%	1.72%	27.63	-3.65%
RCP8.5	NorESM1-M	Tariff elimination	2.06%	1.85%	25.23	-3.82%
RCP8.5	HadGEM2-ES	Tariff elimination	1.79%	1.67%	31.95	-3.64%
RCP8.5 wo	HadGEM2-ES	Tariff elimination	1.53%	1.17%	18.11	-2.54%
NoCC	None	Facilitation + Tariff	2.03%	0.06%	65.49	-9.75%
RCP2.6	HadGEM2-ES	Facilitation + Tariff	2.87%	1.57%	73.87	-11.23%
RCP4.5	HadGEM2-ES	Facilitation + Tariff	2.14%	1.36%	67.91	-10.93%
RCP6.0	HadGEM2-ES	Facilitation + Tariff	2.98%	1.98%	72.34	-11.53%
RCP8.5	GFDL-ESM2M	Facilitation + Tariff	2.52%	1.37%	75.56	-11.77%
RCP8.5	IPSL-CM5A-LR	Facilitation + Tariff	2.52%	1.96%	69.11	-11.43%
RCP8.5	MIROC	Facilitation + Tariff	1.55%	1.17%	71.06	-11.85%
RCP8.5	NorESM1-M	Facilitation + Tariff	2.15%	1.56%	75.34	-11.95%
RCP8.5	HadGEM2-ES	Facilitation + Tariff	2.70%	2.36%	68.54	-10.96%
RCP8.5 wo	HadGEM2-ES	Facilitation + Tariff	2.35%	1.60%	53.64	-8.72%

GCM MIROC: MIROC-ESM-CHEM

Supplementary Table 3 | Impact of crop yields and trade costs on risk of hunger and food availability by region. Results from OLS regression of the impact of crop yield change (1), trade costs (2), and both (3) on food availability and risk of hunger including regional interaction effects. Regression models and sample are described in Method.

		Population at risk of hunger (million)			Food availability (kcal/cap/day)		
		(1)	(2)	(3)	(1)	(2)	(3)
Crop yield (% change)	CSI	-0.56 *		-0.37	223.36 ***		233.73 ***
		(0.31)		(0.34)	(32.47)		(40.29)
	EAS	-10.74		-12.78 ***	230.18		267.68 ***
		(9.43)		(4.18)	(175.86)		(69.10)
	LAC	-6.52 ***		-3.24 ***	355.64 ***		283.90 ***
		(1.90)		(1.24)	(76.29)		(63.92)
	MNA	-0.20		1.76	175.42		137.27 ***
		(7.29)		(2.87)	(139.37)		(51.39)
	OCE	-0.19		-0.27	214.93		192.17
		(0.15)		(0.31)	(161.74)		(291.50)
	SAS	-81.21 ***		-82.83 ***	485.73 ***		475.97 ***
		(16.18)		(21.66)	(73.48)		(93.33)
	SEA	-10.94 **		-11.21 *	372.98 ***		383.02 ***
		(5.42)		(5.85)	(116.26)		(121.74)
	SSA	-105.86 ***		-29.70	928.48 **		317.41
		(38.34)		(22.43)	(365.54)		(254.20)
	USA	-0.07 ***		-0.06	156.78 ***		136.54 *
		(0.02)		(0.04)	(47.00)		(74.61)
Trade cost (log of US$/106 kcal)	CSI		0.49 ***	0.48 ***		-31.78 ***	-28.47 *
			(0.09)	(0.12)		(11.85)	(14.25)
	EAS		6.99 ***	6.61 ***		-137.53 ***	-132.81 ***
			(0.46)	(0.45)		(8.38)	(7.41)
	LAC		1.16 ***	1.07 ***		-21.60 ***	-17.53 *
			(0.20)	(0.18)		(7.52)	(7.94)
	MNA		11.36 ***	11.36 ***		-233.76 ***	-231.44 ***
			(0.47)	(0.55)		(11.98)	(10.97)
	OCE		-0.16 ***	-0.17 ***		172.75 ***	174.33 ***
			(0.03)	(0.05)		(31.88)	(51.23)
	SAS		5.42 ***	5.39 *		-27.80 ***	-32.17 *
			(2.03)	(3.02)		(10.20)	(15.00)
	SEA		-0.11	0.00		15.28	11.11
			(0.53)	(0.63)		(12.96)	(14.33)
	SSA		26.18 ***	24.29 ***		-257.76 ***	-248.05 ***
			(2.56)	(2.41)		(15.77)	(16.51)
	USA		0.03 ***	0.03 ***		-67.11 ***	-58.26 ***
			(0.01)	(0.01)		(15.39)	(16.30)
Crop yield x Trade cost	CSI			-0.19			112.59 ***
				(0.33)			(34.44)
	EAS			-10.56			140.65
				(7.95)			(91.48)
	LAC			8.32			-201.69
				(5.93)			(216.83)
	MNA			3.24			-81.95
				(3.19)			(72.73)
	OCE			-0.04			180.52
				(0.28)			(237.69)
	SAS			-2.18			-33.26
				(26.74)			(104.01)
	SEA			1.47			-55.54
				(6.32)			(120.10)
	SSA			-41.85			-15.56
				(29.88)			(186.45)
	USA			-0.01			14.40
				(0.05)			(79.25)

Significance levels: *p<0.1; **p<0.05; ***p<0.01. Heteroskedastic robust standard errors in brackets. EUR and CAN are not included as zero hunger. N = 450. Adjusted R squared is 0.999 for food availability (1) - (3) and 0.947 (1), 0.961 (2) and 0.976 (3) for hunger regressions.

Supplementary Table 4 | Aggregate regions, GLOBIOM regions and countries.

Aggregate Region	*GLOBIOM Region*	*Country*
CAN	Canada	Canada
CSI	Former USSR	Belarus, Moldova, Ukraine, Russia, Azerbaidjan, Kazakhstan, Turkmenistan, Uzbekistan, Armenia, Georgia, Kyrgyzstan, Tajikistan
EAS	China	People's Republic of China, Hong Kong
	Japan	Japan
	South Korea	Korea
EUR	EU Baltic	Estonia, Latvia, Lithuania
	EU Central East	Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia
	EU Mid-West	Austria, Belgium, France, Germany, Luxembourg, Netherlands
	EU North	Denmark, Finland, Ireland, Sweden, United Kingdom
	EU South	Cyprus, Greece, Italy, Malta, Portugal, Spain
	Rest of Central Eastern Europe (RCEU)	Albania, Bosnia Herzegovina, Croatia, Macedonia, Serbia
	Rest of Western Europe (ROWE)	Iceland, Norway, Switzerland, Greenland
LAC	Brazil	Brazil
	Mexico	Mexico
	Central America (RCAM)	Bahamas, Belize, Costa Rica, Cuba, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Jamaica, Nicaragua, Panama, Trinidad and Tobago
	South America (RSAM)	Argentina, Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela
MNA	Middle East and North Africa	Egypt, Algeria, Libya, Morocco, Tunisia, Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen
	Turkey	Turkey
OCE	ANZ	Australia, New Zealand
	Pacific Islands	Fiji, French Polynesia, New Caledonia, Papua New Guinea, Samoa, Solomon Islands, Vanuatu
SAS	India	India
	Rest of South Asia (RSAS)	Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan, Sri Lanka
SEA	South East Asia – other Pacific Asia (RSEA_OPA)	Brunei Daressalam, Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, East Timor
	South East Asia – (ex-)planned economies (RSEA_PAC)	Cambodia, DPR of Korea, Laos, Mongolia, Viet Nam
SSA	Congo Basin	Cameroon, Central African Republic, Congo Republic, Democratic Republic of Congo, Equatorial Guinea, Gabon
	Eastern Africa	Burundi, Ethiopia, Kenya, Tanzania, Uganda, Rwanda
	South Africa	South Africa
	Southern Africa	Angola, Botswana, Comoros, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Reunion, Swaziland, Zambia, Zimbabwe
	Western Africa and Rest of Sub-Saharan Africa	Benin, Burkina Faso, Cape Verde, Chad, Côte d'Ivoire, Djibouti, Eritrea, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Somalia, Sudan, Togo
USA	USA Region	United States, Puerto Rico

Supplementary Table 5 | Descriptive statistics of the dependent and explanatory variables (at regional level). The sample is composed of observations for the 11 regions for five trade scenarios (Baseline, pre-Doha tariffs, Facilitation, Tariff elimination, and Facilitation + Tariff elimination) and 10 climate change scenarios (N = 550).

	Min	Average	Max
Population at risk of hunger (million)	0.00	12.04	63.06
Food availability (kcal/cap/day)	2518	3074	3510
Crop yield (difference with NoCC)	-38%	-5%	+35%
Trade costs (US$/$10^6$ kcal)	17.91	73.93	225.66

Supplementary Table 6 | Average ad valorem tariffs on GLOBIOM agricultural goods in 2001 and 2010. Tariff rates from MAcMap-HS6 database 2001 and 2010 with weighted average by macro-region and product based on MAcMap reference group weights[1,2]. Specific tariffs are converted to ad valorem equivalent with MAcMap unit values.

	All agricultural goods			
	2001		2010	
REGION	import	export	import	export
CAN	16.63%	7.73%	26.86%	11.41%
CSI	14.02%	12.41%	12.16%	15.21%
EAS	39.15%	22.91%	27.51%	14.12%
EUR	14.10%	14.23%	9.49%	12.65%
LAC	19.96%	19.09%	14.28%	14.87%
MNA	19.68%	21.00%	18.54%	19.31%
OCE	1.89%	30.55%	1.97%	25.04%
SAS	47.21%	27.98%	31.45%	21.70%
SEA	9.63%	21.49%	4.32%	16.51%
SSA	21.98%	10.40%	14.70%	7.86%
USA	4.45%	20.39%	4.79%	15.56%
	Wheat			
	2001		2010	
REGION	import	export	import	export
CAN	1.59%	14.06%	0.00%	20.42%
CSI	10.43%	19.41%	5.41%	28.01%
EAS	28.70%	22.85%	63.16%	10.31%
EUR	12.37%	17.00%	7.95%	17.53%
LAC	9.78%	12.36%	5.29%	26.38%
MNA	16.60%	14.96%	17.84%	21.10%
OCE	0.03%	16.32%	0.03%	20.70%
SAS	67.42%	15.08%	25.60%	17.92%
SEA	7.77%	25.88%	2.52%	19.15%
SSA	11.66%	16.09%	5.73%	18.08%
USA	2.37%	15.15%	1.46%	20.43%

Supplementary Table 6 *continued.*

	Corn			
	2001		2010	
REGION	import	export	import	export
CAN	0.00%	17.24%	0.00%	24.83%
CSI	8.87%	21.54%	2.14%	33.52%
EAS	67.84%	30.98%	82.49%	18.45%
EUR	19.39%	20.36%	1.82%	19.35%
LAC	35.90%	25.38%	5.43%	28.14%
MNA	25.96%	13.30%	29.86%	12.47%
OCE	0.05%	26.33%	0.13%	18.42%
SAS	41.65%	11.48%	9.46%	18.49%
SEA	17.86%	27.34%	4.48%	17.97%
SSA	27.80%	28.40%	7.37%	11.43%
USA	1.06%	30.09%	0.32%	23.52%
	Rice			
	2001		2010	
REGION	import	export	import	export
CAN	0.00%	100.96%	0.00%	30.71%
CSI	8.95%	31.17%	14.60%	34.24%
EAS	362.15%	52.40%	116.56%	29.45%
EUR	71.19%	81.67%	16.70%	27.32%
LAC	21.48%	37.22%	13.67%	33.46%
MNA	18.51%	34.70%	13.60%	35.93%
OCE	0.00%	74.20%	0.32%	23.82%
SAS	56.15%	60.86%	25.84%	30.20%
SEA	14.76%	89.21%	21.75%	26.92%
SSA	28.34%	36.85%	10.80%	20.21%
USA	4.15%	70.13%	2.17%	29.06%
	Soya			
	2001		2010	
REGION	import	export	import	export
CAN	0.00%	20.57%	0.00%	17.00%
CSI	2.87%	28.40%	0.13%	10.18%
EAS	130.66%	18.22%	17.99%	20.27%
EUR	1.90%	20.67%	0.87%	16.13%
LAC	3.83%	25.52%	3.66%	7.61%
MNA	3.79%	21.88%	3.40%	3.18%
OCE	0.03%	22.12%	0.40%	17.66%
SAS	27.42%	18.87%	26.82%	15.71%
SEA	6.01%	33.85%	1.51%	3.71%
SSA	3.43%	11.53%	6.78%	9.08%
USA	0.00%	25.27%	0.00%	6.52%

Supplementary Table 7 | Average total trade cost (USD/ton) on agricultural trade for each region in 2000 and 2010, and in 2050 across trade scenarios. The aggregation is described in Method.

Trade scenario	Region	Tariff cost	Transport cost	Trade expansion cost[1]	Total trade cost
2000 – Baseline trade	CAN	37	248	/	285
	CSI	35	389	/	424
	EAS	185	721	/	906
	EUR	44	353	/	398
	LAC	37	261	/	298
	MNA	33	272	/	305
	OCE	126	812	/	937
	SAS	173	211	/	384
	SEA	89	581	/	670
	SSA	35	494	/	530
	USA	57	283	/	339
2010 – Baseline trade	CAN	25	215	28	268
	CSI	19	314	33	365
	EAS	219	499	129	846
	EUR	20	328	34	382
	LAC	29	250	29	308
	MNA	24	243	27	294
	OCE	120	508	147	775
	SAS	117	184	53	354
	SEA	177	560	74	811
	SSA	22	412	46	480
	USA	32	236	25	293
2050 – Baseline trade	CAN	20	139	6	165
	CSI	12	188	9	209
	EAS	61	107	11	179
	EUR	17	163	20	200
	LAC	14	147	11	171
	MNA	18	143	38	199
	OCE	256	117	58	431
	SAS	62	75	18	155
	SEA	38	126	11	175
	SSA	18	86	16	121
	USA	24	92	18	135
2050 – Pre-Doha tariff levels	CAN	8	142	8	158
	CSI	18	262	8	288
	EAS	98	267	6	371
	EUR	20	228	24	272
	LAC	23	186	9	218
	MNA	24	181	53	258
	OCE	54	294	48	397
	SAS	189	130	25	343
	SEA	103	339	16	458
	SSA	23	206	19	249
	USA	36	187	10	233

Supplementary Table 7 *continued.*

Trade scenario	Region	Tariff cost	Transport cost	Trade expansion cost[1]	Total trade cost
2050 – Trade facilitation	CAN	27	125	7	160
	CSI	12	111	2	125
	EAS	62	76	1	139
	EUR	23	90	1	115
	LAC	18	106	3	127
	MNA	26	94	5	125
	OCE	231	71	9	311
	SAS	48	71	2	121
	SEA	36	99	2	137
	SSA	42	108	4	154
	USA	36	79	3	118
2050 – Tariff elimination	CAN	0	131	15	146
	CSI	0	144	21	164
	EAS	0	68	15	83
	EUR	0	100	34	135
	LAC	0	101	16	117
	MNA	0	104	36	140
	OCE	0	96	48	143
	SAS	0	64	19	83
	SEA	0	103	16	119
	SSA	0	79	26	105
	USA	0	76	21	97
2050 – Trade facilitation + Tariff elimination	CAN	0	97	5	102
	CSI	0	64	24	88
	EAS	0	64	5	69
	EUR	0	71	20	91
	LAC	0	67	3	70
	MNA	0	71	6	78
	OCE	0	88	24	112
	SAS	0	52	3	55
	SEA	0	84	3	86
	SSA	0	99	4	103
	USA	0	49	3	52

[1] The trade expansion cost reflects the cost of infrastructure and capacity constraints in the transport sector and is reset to zero after a decade if the traded quantity does not increase anymore. It is not present in the base year 2000.

Supplementary Table 8 | Corn trade pattern in response to climate change (RCP8.5 scenarios under *Baseline trade*) at macro-region level. Bilateral trade flows among 30 sub-regions are aggregated to reflect inter-regional trade among macro-regions and the magnitude of intra-regional trade. No climate change gives the trade volume (1000 ton) in the SSP2 baseline. Min and max CC impact give the minimum and maximum trade change (%) that occurs across RCP8.5 scenarios. Min and max CC new trade give the minimum and maximum trade volume (1000 ton) across RCP8.5 scenarios that is new compared to the SSP2 baseline.

Exporter		Importer										
		CAN	**CSI**	**EAS**	**EUR**	**LAC**	**MNA**	**OCE**	**SAS**	**SEA**	**SSA**	**USA**
CAN	No climate change	0	0	0	0	0	0	0	0	0	0	0
	Min CC impact (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Max CC impact (%)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Min CC new trade	0	0	0	0	45	0	0	0	0	0	0
	Max CC new trade	0	0	0	0	45	0	0	0	0	0	0
CSI	No climate change	0	0	0	37	0	1393	0	0	0	0	0
	Min trade growth	0%	0%	0%	-1%	0%	14%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	0%	221%	0%	106%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
EAS	No climate change	0	0	5357	0	0	0	0	0	8580	0	0
	Min trade growth	0%	0%	-5%	0%	0%	0%	0%	0%	-8%	0%	0%
	Max trade growth	0%	0%	22%	0%	0%	0%	0%	0%	113%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
EUR	No climate change	0	0	2407	25938	0	2662	0	0	1773	0	0
	Min trade growth	0%	0%	-25%	-15%	0%	18%	0%	0%	-4%	0%	0%
	Max trade growth	0%	0%	85%	13%	0%	127%	0%	0%	114%	0%	0%
	Min new trade	0	573	0	0	0	0	0	0	0	0	0
	Max new trade	0	573	660	0	0	1522	0	0	0	0	0
LAC	No climate change	13643	0	0	10112	52812	7945	0	14776	4147	17419	0
	Min trade growth	-71%	0%	0%	1%	-2%	5%	0%	-40%	-64%	-37%	0%
	Max trade growth	-41%	0%	0%	44%	8%	114%	0%	222%	72%	4%	0%
	Min new trade	0	0	2069	0	0	0	0	0	0	0	0
	Max new trade	0	0	2151	0	0	0	0	0	0	0	0
MNA	No climate change	0	0	0	14659	0	0	0	0	0	0	0
	Min trade growth	0%	0%	0%	-59%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	0%	-10%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	336	0	0	0	0	0
	Max new trade	0	0	0	0	0	798	0	0	0	0	0
OCE	No climate change	0	0	677	0	0	0	0	0	0	0	0
	Min trade growth	0%	0%	-30%	0%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	9%	0%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	2	0	130	0	0
	Max new trade	0	0	0	0	0	0	8	0	221	0	0
SAS	No climate change	0	0	0	0	0	0	0	0	8393	0	0
	Min trade growth	0%	0%	0%	0%	0%	0%	0%	0%	12%	0%	0%
	Max trade growth	0%	0%	0%	0%	0%	0%	0%	0%	126%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
SEA	No climate change	0	0	12015	0	0	0	0	0	0	0	0
	Min trade growth	0%	0%	-16%	0%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	11%	0%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	542	0	0
	Max new trade	0	0	0	0	0	0	0	0	3704	0	0

Supplementary Table 8 ***continued.***

Exporter		Importer										
		CAN	CSI	EAS	EUR	LAC	MNA	OCE	SAS	SEA	SSA	USA
SSA	No climate change	0	0	21455	0	2548	13936	0	0	2033	0	0
	Min trade growth	0%	0%	-49%	0%	-84%	-93%	0%	0%	4%	0%	0%
	Max trade growth	0%	0%	8%	0%	49%	-1%	0%	0%	169%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	517	0	0	0	0	0	0	0	0
USA	No climate change	0	0	0	6131	1437	14442	491	97388	0	4382	0
	Min trade growth	0%	0%	0%	-99%	4%	-15%	0%	-88%	0%	-75%	0%
	Max trade growth	0%	0%	0%	90%	738%	35%	132%	36%	0%	107%	0%
	Min new trade	5669	0	10516	0	0	0	0	0	91	0	0
	Max new trade	5669	0	10516	0	4865	0	0	537	3343	165	0

Supplementary Table 9 | Rice trade pattern in response to climate change (RCP8.5 scenarios under *Baseline trade*) at macro-region level. Bilateral trade flows among 30 sub-regions are aggregated to reflect inter-regional trade among macro-regions and the magnitude of intra-regional trade. No climate change gives the trade volume (1000 ton) in the SSP2 baseline. Min and max CC impact give the minimum and maximum trade change (%) that occurs across RCP8.5 scenarios. Min and max CC new trade give the minimum and maximum trade volume (1000 ton) across RCP8.5 scenarios that is new compared to the SSP2 baseline.

		Importer										
Exporter		**CAN**	**CSI**	**EAS**	**EUR**	**LAC**	**MNA**	**OCE**	**SAS**	**SEA**	**SSA**	**USA**
EAS	No climate change	0	0	0	0	170	33	0	0	630	71663	0
	Min trade growth	0%	0%	0%	0%	-6%	-6%	0%	0%	0%	-3%	0%
	Max trade growth	0%	0%	0%	0%	7%	11%	0%	0%	170%	1%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
EUR	No climate change	619	0	0	316	5554	17432	0	0	0	2304	0
	Min trade growth	0%	0%	0%	-75%	-70%	-39%	0%	0%	0%	-16%	0%
	Max trade growth	0%	0%	0%	-6%	5%	2%	0%	0%	0%	57%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	1	0	0	0	0	0
LAC	No climate change	0	0	0	2805	6730	743	0	0	0	834	0
	Min trade growth	0%	0%	0%	2%	-8%	-15%	0%	0%	0%	-3%	0%
	Max trade growth	0%	0%	0%	104%	24%	73%	0%	0%	0%	125%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	296	0	0	0	0	0	640	0
MNA	No climate change	0	0	0	1255	0	0	0	0	0	0	0
	Min trade growth	0%	0%	0%	-33%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
OCE	No climate change	0	0	0	290	0	0	0	0	0	0	0
	Min trade growth	0%	0%	0%	-7%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
SAS	No climate change	0	88	0	1525	0	1957	175	0	9038	1098	0
	Min trade growth	0%	0%	0%	-7%	0%	-97%	-59%	0%	-18%	-79%	0%
	Max trade growth	0%	0%	0%	8%	0%	5%	111%	0%	287%	4%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
SEA	No climate change	0	0	78592	939	0	0	294	54530	0	414	3097
	Min trade growth	0%	0%	-3%	-41%	0%	0%	-49%	-23%	0%	-21%	-60%
	Max trade growth	0%	0%	1%	6%	0%	0%	18%	12%	0%	6%	486%
	Min new trade	0	0	0	0	0	1	0	0	0	0	0
	Max new trade	0	0	0	104	0	84	0	0	0	0	0
SSA	No climate change	0	0	0	119	58	0	0	0	0	58	0
	Min trade growth	0%	0%	0%	-15%	-17%	0%	0%	0%	0%	-17%	0%
	Max trade growth	0%	0%	0%	3%	5%	0%	0%	0%	0%	1%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0

Supplementary Table 9 *continued.*

Exporter		Importer										
		CAN	**CSI**	**EAS**	**EUR**	**LAC**	**MNA**	**OCE**	**SAS**	**SEA**	**SSA**	**USA**
USA	No climate change	0	0	0	24310	0	0	0	0	0	0	0
	Min trade growth	0%	0%	0%	-49%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	0%	-5%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	108	0	0	0	0
	Max new trade	0	0	0	369	0	0	108	0	0	0	0

Supplementary Table 10 | Wheat trade pattern in response to climate change (RCP8.5 scenarios under *Baseline trade*) at macro-region level. Bilateral trade flows among 30 sub-regions are aggregated to reflect inter-regional trade among macro-regions and the magnitude of intra-regional trade. No climate change gives the trade volume (1000 ton) in the SSP2 baseline. Min and max CC impact give the minimum and maximum trade change (%) that occurs across RCP8.5 scenarios. Min and max CC new trade give the minimum and maximum trade volume (1000 ton) across RCP8.5 scenarios that is new compared to the SSP2 baseline.

Exporter		**Importer**										
		CAN	**CSI**	**EAS**	**EUR**	**LAC**	**MNA**	**OCE**	**SAS**	**SEA**	**SSA**	**USA**
CAN	No climate change	0	0	5961	0	1056	0	0	0	0	2503	8185
	Min trade growth	0%	0%	-1%	0%	67%	0%	0%	0%	0%	-48%	126%
	Max trade growth	0%	0%	0%	0%	67%	0%	0%	0%	0%	-48%	262%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
CSI	No climate change	0	0	1733	4391	0	11553	0	0	0	0	0
	Min trade growth	0%	0%	-35%	-73%	0%	-27%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	125%	153%	0%	60%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	5872	0	0	0	0	0	0	0
EAS	No climate change	0	0	4600	0	0	0	0	0	0	0	0
	Min trade growth	0%	0%	-47%	0%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	13%	0%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
EUR	No climate change	0	360	42	13319	13222	2456	0	0	14637	18336	0
	Min trade growth	0%	-68%	438%	-45%	66%	-4%	0%	0%	-2%	12%	0%
	Max trade growth	0%	54%	593%	37%	74%	410%	0%	0%	1%	34%	0%
	Min new trade	0	0	0	0	0	0	0	112	0	0	0
	Max new trade	0	0	7	0	0	0	0	602	0	0	0
LAC	No climate change	0	0	0	0	0	6930	0	515	0	2156	0
	Min trade growth	0%	0%	0%	0%	0%	-17%	0%	1%	0%	3%	0%
	Max trade growth	0%	0%	0%	0%	0%	49%	0%	157%	0%	26%	0%
	Min new trade	0	75	0	0	0	0	0	0	0	0	0
	Max new trade	0	75	0	0	0	0	0	2	0	0	0
MNA	No climate change	0	0	0	18500	0	0	0	0	0	12649	0
	Min trade growth	0%	0%	0%	58%	0%	0%	0%	0%	0%	19%	0%
	Max trade growth	0%	0%	0%	80%	0%	0%	0%	0%	0%	42%	0%
	Min new trade	0	0	0	0	0	1085	0	0	0	0	0
	Max new trade	0	0	0	0	0	1085	0	0	0	1466	0
OCE	No climate change	0	0	0	0	0	0	228	59506	0	0	0
	Min trade growth	0%	0%	0%	0%	0%	0%	-5%	-11%	0%	0%	0%
	Max trade growth	0%	0%	0%	0%	0%	0%	0%	39%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
SAS	No climate change	0	0	0	0	0	0	0	5711	0	0	0
	Min trade growth	0%	0%	0%	0%	0%	0%	0%	-57%	0%	0%	0%
	Max trade growth	0%	0%	0%	0%	0%	0%	0%	40%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
SEA	No climate change	0	0	3	0	0	0	0	0	63	4	0
	Min trade growth	0%	0%	9%	0%	0%	0%	0%	0%	25%	-52%	0%
	Max trade growth	0%	0%	66%	0%	0%	0%	0%	0%	125%	12%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0

Supplementary Table 10 *continued.*

Exporter		Importer										
		CAN	CSI	EAS	EUR	LAC	MNA	OCE	SAS	SEA	SSA	USA
SSA	No climate change	0	2	3	4	1	1	8	1	0	4	0
	Min trade growth	0%	-58%	-2%	-80%	-26%	43%	-8%	51%	0%	-28%	0%
	Max trade growth	0%	13%	51%	96%	68%	51%	59%	480%	0%	1394%	0%
	Min new trade	0	0	0	0	0	0	0	2	0	0	0
	Max new trade	0	0	0	2	0	0	0	3	0	58	0
USA	No climate change	0	0	0	0	0	0	0	21859	0	0	0
	Min trade growth	0%	0%	0%	0%	0%	0%	0%	-99%	0%	0%	0%
	Max trade growth	0%	0%	0%	0%	0%	0%	0%	-36%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0

Supplementary Table 11 | Soya trade pattern in response to climate change (RCP8.5 scenarios under *Baseline trade*) at macro-region level. Bilateral trade flows among 30 sub-regions are aggregated to reflect inter-regional trade among macro-regions and the magnitude of intra-regional trade. No climate change gives the trade volume (1000 ton) in the SSP2 baseline. Min and max CC impact give the minimum and maximum trade change (%) that occurs across RCP8.5 scenarios. Min and max CC new trade give the minimum and maximum trade volume (1000 ton) across RCP8.5 scenarios that is new compared to the SSP2 baseline.

Exporter		**Importer**										
		CAN	**CSI**	**EAS**	**EUR**	**LAC**	**MNA**	**OCE**	**SAS**	**SEA**	**SSA**	**USA**
CAN	No climate change	0	0	3994	160	0	0	0	0	437	0	0
	Min trade growth	0%	0%	-10%	-14%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	11%	2%	0%	0%	0%	0%	15%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	1
	Max new trade	0	0	0	0	0	0	0	0	0	0	1
CSI	No climate change	0	0	16418	0	0	0	0	0	0	0	0
	Min trade growth	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	12%	0%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
EAS	No climate change	0	0	1294	0	0	0	0	0	0	0	0
	Min trade growth	0%	0%	-33%	0%	0%	0%	0%	0%	0%	0%	0%
	Max trade growth	0%	0%	-1%	0%	0%	0%	0%	0%	0%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	3	0
	Max new trade	0	0	6	0	0	0	0	0	0	3	0
EUR	No climate change	0	10313	6171	8137	1199	908	910	0	7088	2999	0
	Min trade growth	0%	3%	-73%	26%	-7%	0%	-40%	0%	16%	-1%	0%
	Max trade growth	0%	10%	-63%	64%	208%	19%	21%	0%	60%	23%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	465	3	0	0	0	0	145	0
LAC	No climate change	5375	1029	50840	59989	22140	23805	217	18666	14279	835	0
	Min trade growth	-29%	-55%	8%	-7%	-22%	-5%	-8%	46%	3%	-30%	0%
	Max trade growth	67%	12%	13%	13%	4%	9%	13%	89%	26%	-1%	0%
	Min new trade	0	0	0	0	0	0	0	249	0	0	0
	Max new trade	0	0	382	0	1	0	1	1327	0	2	0
MNA	No climate change	0	4033	0	0	0	0	0	0	0	0.08	0
	Min trade growth	0%	9%	0%	0%	0%	0%	0%	0%	0%	478%	0%
	Max trade growth	0%	22%	0%	0%	0%	0%	0%	0%	0%	1256%	0%
	Min new trade	0	0	0	0	0	0	0	276	0	0	0
	Max new trade	0	0	0	0	1	0	0	593	0	0	0
OCE	No climate change	0	0	42	0	0	0	0	0	675	0	0
	Min trade growth	0%	0%	0%	0%	0%	0%	0%	0%	7%	0%	0%
	Max trade growth	0%	0%	33%	0%	0%	0%	0%	0%	28%	0%	0%
	Min new trade	0	0	0	0	0	0	0	23	0	0	0
	Max new trade	0	0	0	0	1	0	0	45	0	0	0
SAS	No climate change	0	0	173	0	1	0	0	9068	4110	0	0
	Min trade growth	0%	0%	-10%	0%	-38%	0%	0%	-35%	-23%	0%	0%
	Max trade growth	0%	0%	206%	0%	117%	0%	0%	-19%	8%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
SEA	No climate change	0	0	7	0	0	0	0	0	1546	0	0
	Min trade growth	0%	0%	-6%	0%	0%	0%	0%	0%	-11%	0%	0%
	Max trade growth	0%	0%	297%	0%	0%	0%	0%	0%	26%	0%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	11	0	0	0	0	0	0	0	0

Supplementary Table 11 *continued.*

Exporter		Importer										
		CAN	CSI	EAS	EUR	LAC	MNA	OCE	SAS	SEA	SSA	USA
SSA	No climate change	0	0	0	0	0	0	0	0	0	546	0
	Min trade growth	0%	0%	0%	0%	0%	0%	0%	0%	0%	-9%	0%
	Max trade growth	0%	0%	0%	0%	0%	0%	0%	0%	0%	54%	0%
	Min new trade	0	0	0	0	0	0	0	0	0	0	0
	Max new trade	0	0	0	0	0	0	0	0	0	0	0
USA	No climate change	0	0	607	1235	5111	284	0	1333	7385	279	0
	Min trade growth	0%	0%	-61%	-58%	-40%	1162%	0%	-67%	-61%	102%	0%
	Max trade growth	0%	0%	3%	28%	8%	1162%	0%	89%	26%	102%	0%
	Min new trade	1983	0	0	0	0	3374	472	0	0	188	0
	Max new trade	1983	0	0	340	0	3374	472	0	264	188	0

Supplementary Table 12 | Technology-induced exogenous crop yield growth rates between 2000 and 2050 under SSP2.

Region	All crops	Corn	Rice	Soya	Wheat
USA	34%	39%	42%	35%	18%
CAN	36%	45%	0%	13%	43%
EUR	44%	66%	17%	37%	39%
CSI	110%	123%	128%	87%	111%
EAS	45%	49%	32%	36%	68%
SEA	67%	140%	60%	64%	166%
SAS	93%	137%	117%	98%	86%
MNA	77%	124%	66%	56%	75%
SSA	114%	185%	108%	154%	56%
LAC	86%	172%	96%	63%	106%
OCE	47%	56%	30%	34%	67%

Supplementary Text

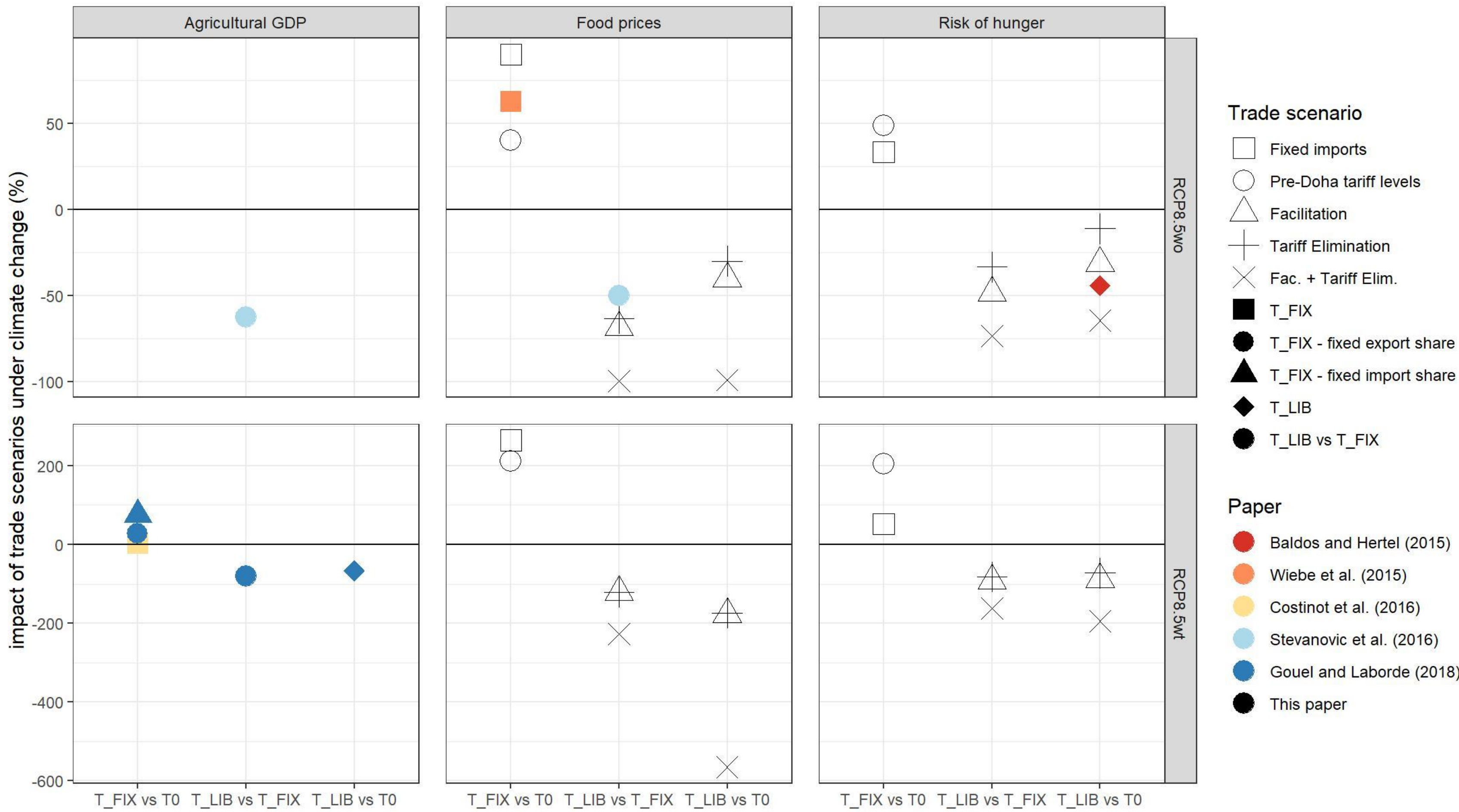
Contribution to existing literature

To determine whether international trade can act as an adaptation mechanism to climate change, global simulation studies assess whether for a particular indicator, the outcome under climate change is worse under a restricted trade setting or better under a liberalized trade setting. Supplementary Table 13 presents an overview of the trade and climate change scenarios assessed in recent literature. Most studies focus on either trade liberalization or trade restriction, or do not compare the impact of trade under climate change to the impact of trade under current climate. By analyzing a comprehensive set of both trade and climate change scenarios, this paper intends to contribute to this research gap and investigates whether the impact of trade becomes larger under climate change.

Supplementary Fig. 5 compares the results in this paper to previous simulation studies. It reveals that there is an agreement on the direction of the impact of trade: trade restriction worsens the adverse impact of climate change on agricultural GDP, prices or risk of hunger, while trade integration alleviates it. It further shows that our scenarios identify a wider range of impacts compared to previous literature. For example, we find that trade restriction increases the adverse impact of climate change on food prices by 40% to 90%, compared to 63% in Wiebe et al[3], or that trade integration reduces the adverse impact of climate change on hunger by 11% to 64%, compared to 44% in Baldos and Hertel[4] (Supplementary Fig. 5).

Supplementary Table 13 | Comparison of global simulation studies[3–9] on climate change adaptation in the agricultural sector through international trade. Overview of scenarios assessed: restricted (T_FIX) or liberalized (T_LIB) trade, under current climate (No CC) or climate change (CC).

Paper	Indicator	Economic model	Climate change scenarios	No CC	No CC + T_FIX	No CC + T_LIB	CC	CC + T_FIX	CC + T_LIB	Trade scenarios
Randhir and Hertel (2000)	Equivalent Variation	GTAP	Crop yield distribution from Tsigas et al. (1997)				x	x	x	T_FIX: market insulation T_LIB: removal of all agricultural trade distortions and producer subsidies
Costinot et al. (2016)	Agr. GDP	Static CGE	SRES A1F1 (~RCP8.5) with CO_2	x			x	x		T_FIX: fixed export share T_LIB: /
Stevanovic et al. (2016)	Agr. GDP, prices	MagPIE	RCP8.5 without CO_2		x	x		x	x	T_FIX: relative share of regional trade is fixed to the level of 1995 T_LIB: reduce trade barriers by 10% per decade
Gouel and Laborde (2018)	Agr. GDP	Static CGE	SRES A1F1 (~RCP8.5) with CO_2	x			x	x	x	T_FIX: fixed import share or fixed export share T_LIB: integrated world markets
Baldos and Hertel (2015)	Hunger	SIMPLE	RCP8.5 without CO_2				x		x	T_FIX: / T_LIB: integrated world market
Wiebe et al. (2015)	Prices	ENVISAGE, FARM, IMPACT, MAGNET, MAgPIE	RCP4.5, RCP6, RCP8.5 without CO_2	x			x	x	x	T_FIX: tariffs between macro-regions doubled T_LIB: removal of tariffs and export subsidies on agri-food trade (phased out over 2020–2035).
Cui et al. (2018)	GDP, prices, …	MAGNET	RCP6 without CO_2	x		x	x		x	T_FIX: / T_LIB: removal of import tariffs, export taxes and export subsidies.
This paper	Hunger, prices	GLOBIOM	RCP2.6, RCP4.5, RCP6, RCP8.5 with CO_2 + RCP8.5 without CO_2	x	x	x	x	x	x	T_FIX: fixed max. import volume or pre-Doha tariff levels T_LIB: removal of tariffs on agricultural trade, trade facilitation or both

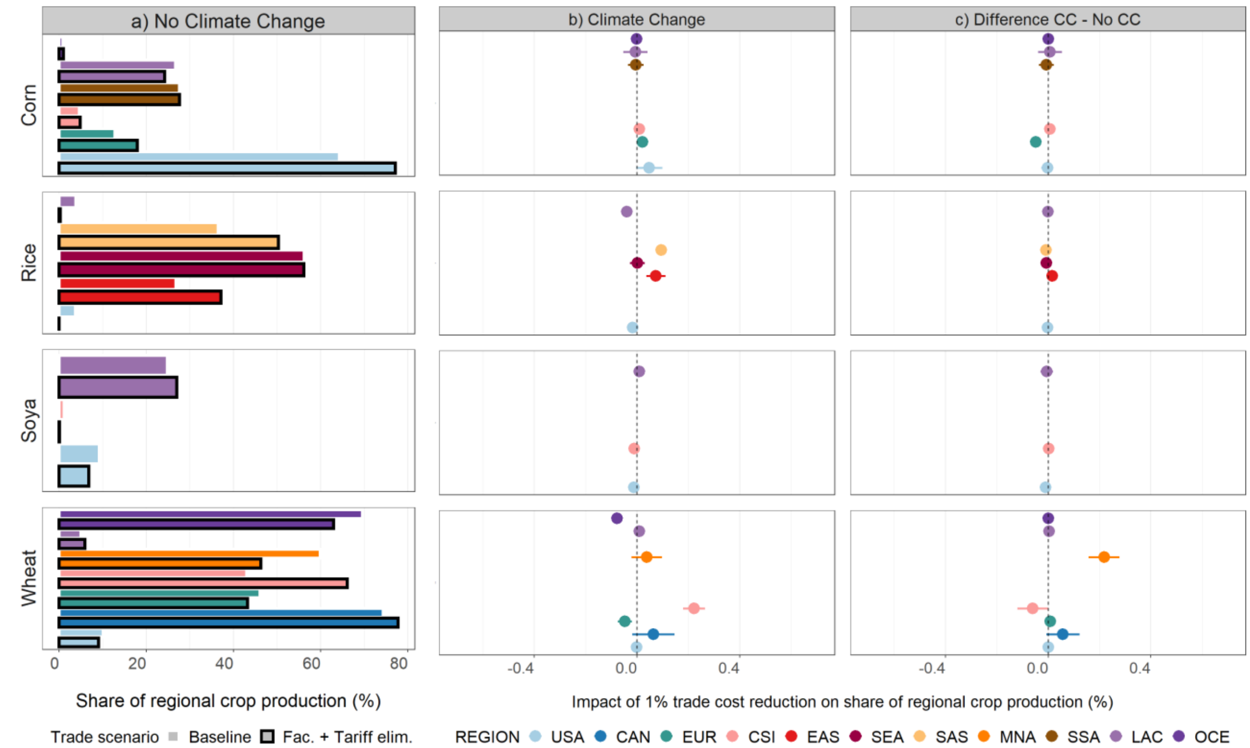


Supplementary Fig. 5 | Comparison of literature on climate change adaptation in agricultural sector through international trade: impact of restricted (T_FIX) or liberalized (T_LIB) trade compared to baseline trade scenario (T0) under RCP8.5 with (wt) or without (wo) CO_2 fertilization. T_FIX vs T0 indicates how restricting trade alters the impact climate change $\left(\frac{Impact\ CC\ under\ T\_FIX}{Impact\ CC\ under\ T0} - 1\right)$. T_LIB vs T0 gives the impact of liberalizing or facilitating trade on climate change effects $\left(1 - \frac{Impact\ CC\ under\ T\_LIB}{Impact\ CC\ under\ T0}\right)$. T_FIX vs T_LIB compares the impact of restricting trade compared to open trade under climate change $\left(1 - \frac{Impact\ CC\ under\ T\_LIB}{Impact\ CC\ under\ T\_FIX}\right)$. For details on the restricted (T_FIX) and liberalized (T_LIB) trade scenarios of each paper, see Supplementary Table 13.

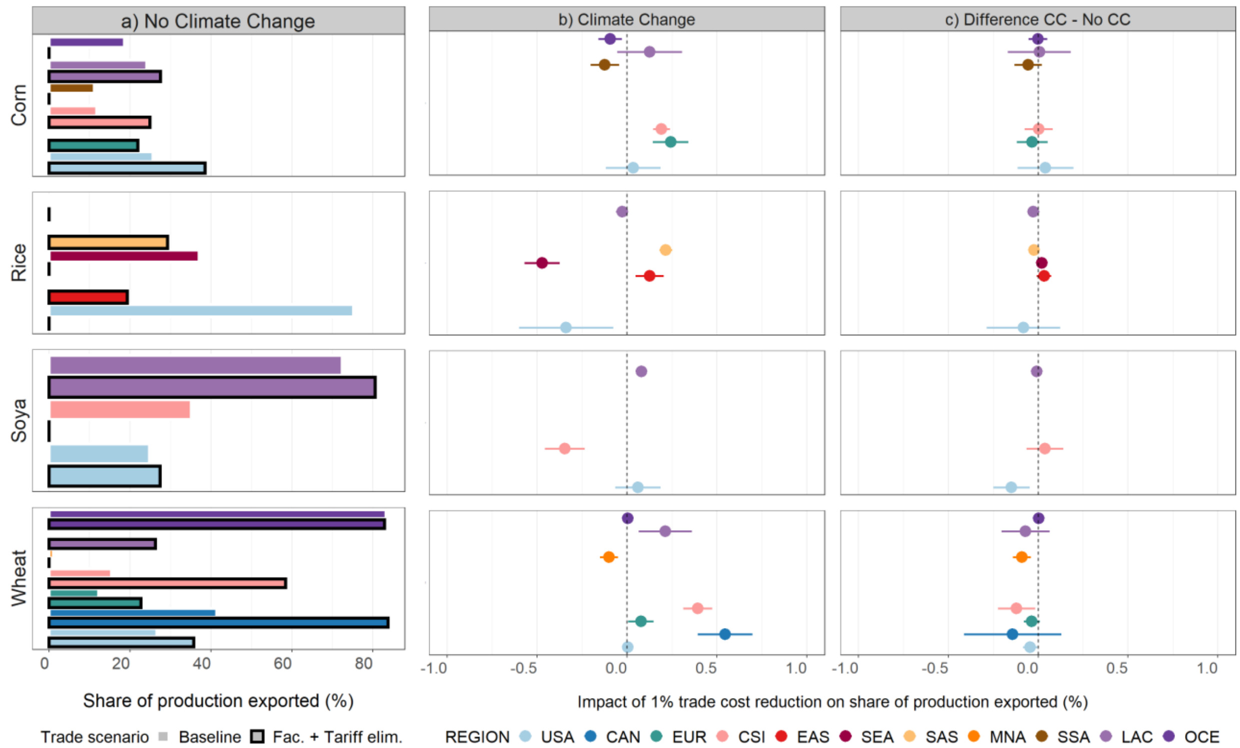
Comparative advantage analysis

Ricardo's theory of comparative advantage postulates that a country has a comparative advantage if the opportunity cost of producing a certain good in terms of other goods is smaller than it is in other countries[10]. Trade benefits countries when they export goods for which they have a comparative advantage through gains in efficiency and consumption possibilities. Less resources are needed for the same level of consumption, or equivalently, a higher consumption level can be reached for the same amount of resources. Our indicators of comparative advantage are inspired by the application of Ricardo's trade theory to a multi-country multi-good setting by Constinot et al.[11]. They propose that when trade barriers are removed, a country should not produce and export only the goods for which it has a comparative advantage, but it should produce and export relatively more of these goods. Using linear regression models, we estimate whether trade cost reduction increases the share of production of a crop that region represents in total world production of the crop (Fig. 4 in main text), the share of each crop in a region's total crop production (Supplementary Fig. 6), and the share of a region's production that is exported (Supplementary Fig. 7). Production and export effects mostly correspond, but there are some cases where reduced trade costs increase export shares without corresponding increases in production shares, e.g. corn in CSI and EUR, or wheat in CAN. These specialization indicators take into account differences in land productivity, land endowment and competitiveness between crops and regions.

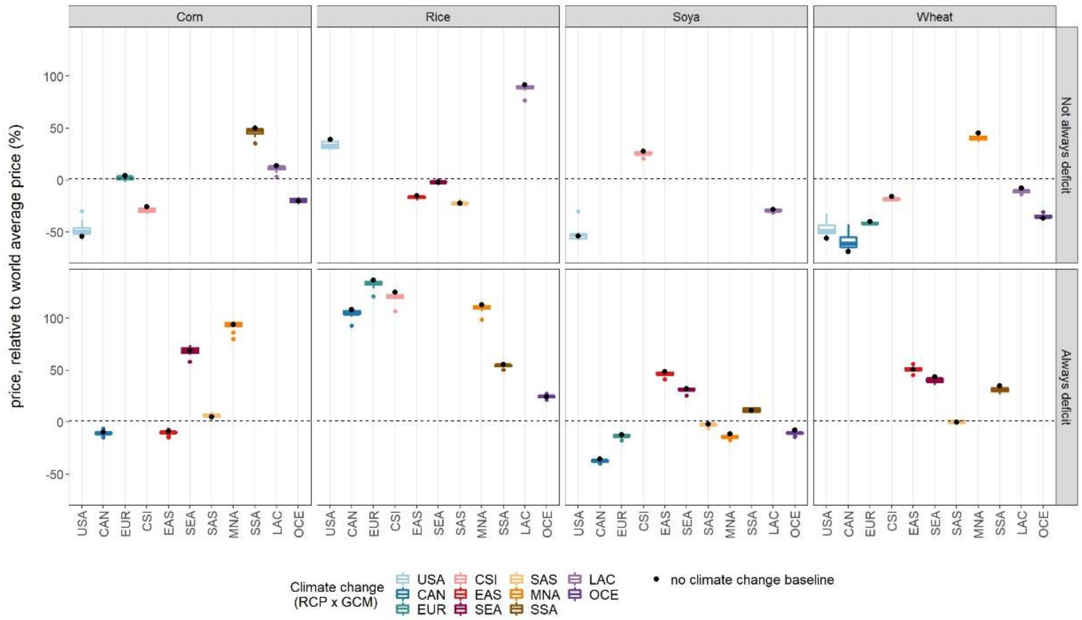
As a robustness check, we report additional indicators of comparative advantage that are common in the literature. The original definition of comparative advantage in the Ricardo trade model states that "*A country has a comparative advantage in producing a good if the opportunity cost of producing that good in terms of other goods is lower in that country than it is in other countries*." (Krugman and Obstfeld[10] p. 14). The assessment of comparative advantages requires tackling the fundamental identification problem of unobserved relative productivity differences across countries under complete specialization[12]. Costinot and Donaldson[13] demonstrate that the identification problem can be solved in the context of agricultural production by using agronomic predictions of crop yields in each country. They define comparative advantage in terms of the relative crop yield (productivity A_{cf}^{g}) between two crops (goods g) and two fields (factors f): *"If two factors located in country c are such that* $\left(\frac{A_{cf_2}^{g_2}}{A_{cf_2}^{g_1}} > \frac{A_{cf_1}^{g_2}}{A_{cf_1}^{g_1}}\right)$ *for two goods* g_1 *and* g_2*, then field* f_2 *has a comparative advantage in good* g_2*".* We use a similar measure, but perform a cross-region comparison with for each crop the ratio of yield to the average yield of all other crops (Supplementary Fig. 8). A second related indicator is the relative competitiveness across crops and regions. GLOBIOM is a perfect competition model implying that producer prices reflect marginal costs. By comparing for each region and crop its producer price to the world average price and regional average crop price, we assess to what extent a region can produce a certain crop at a lower cost compared to other regions and compared to other crops (Supplementary Fig. 9 and 10). Lastly, we report the Balassa Index[14] of Revealed Comparative Advantage (RCA) (Supplementary Fig. 11). RCA compares the export performance of a region in a certain crop with the global export performance for that crop. To exclude the impact of trade barriers on export performance, we calculate the index based on the trade pattern in the *Facilitation + Tariff elimination* scenario.



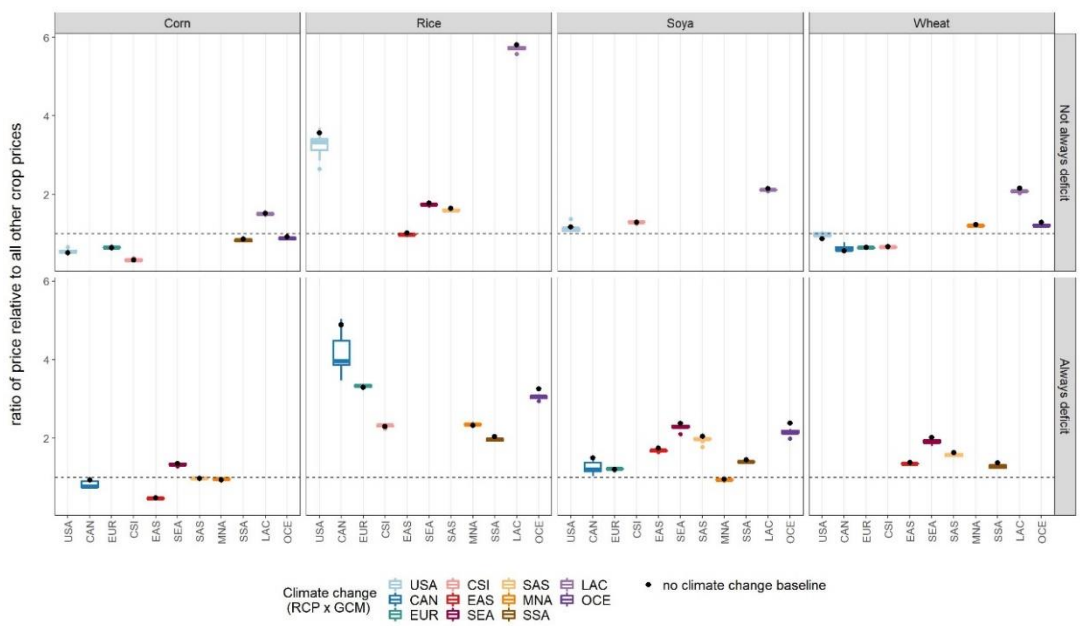
Supplementary Fig. 6 | Intra-regional specialization in corn, rice, soya and wheat in response to trade cost reduction in 2050. **a)** presents the share in total regional crop production under no climate change in *Baseline trade* and *Facilitation + Tariff Elimination*. In **b)** each point shows the estimated impact of a 1% reduction in trade costs for each region on share of regional crop production in percentage, with lines denoting the corresponding 95% confidence interval (heteroskedastic robust standard errors). Idem for **c)**, except that the outcome variable is the difference in share of regional crop production with the no climate change scenario. Regression models are described in Method.



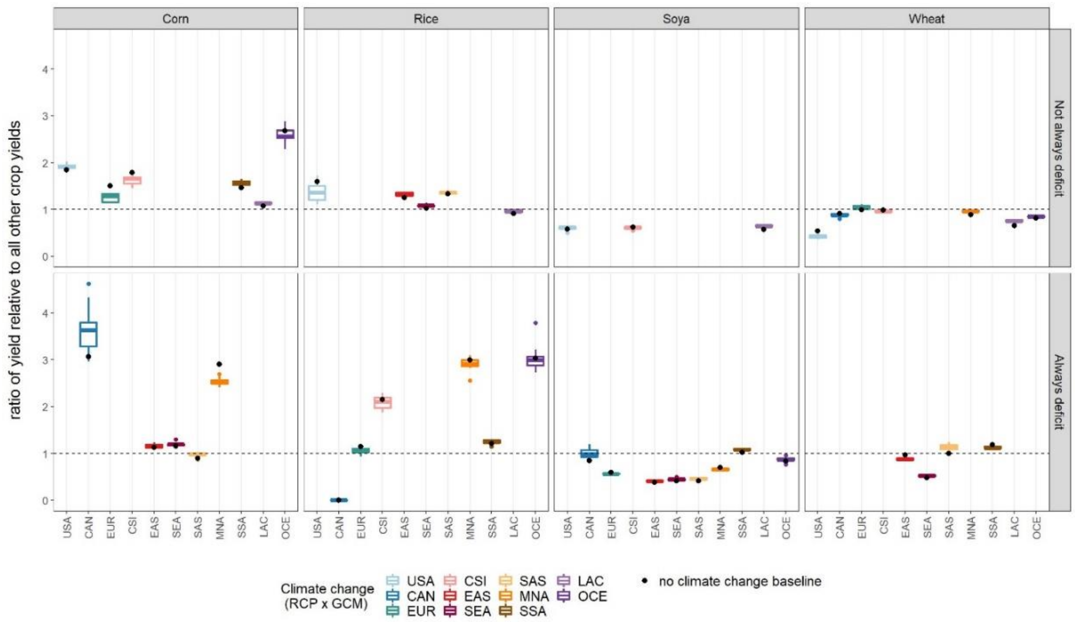
Supplementary Fig. 7 | Export orientation of production in corn, rice, soya and wheat in response to trade cost reduction in 2050. a) presents the share of production exported under no climate change in *Baseline trade* and *Facilitation + Tariff Elimination*. In **b)** each point shows the estimated impact of a 1% trade cost reduction for each region on share of production exported in percentage, with lines denoting the corresponding 95% confidence interval (heteroskedastic robust standard errors). Idem for **c)**, except that the outcome variable is the difference in share of production exported compared to no climate change. Regression models are described in Method.



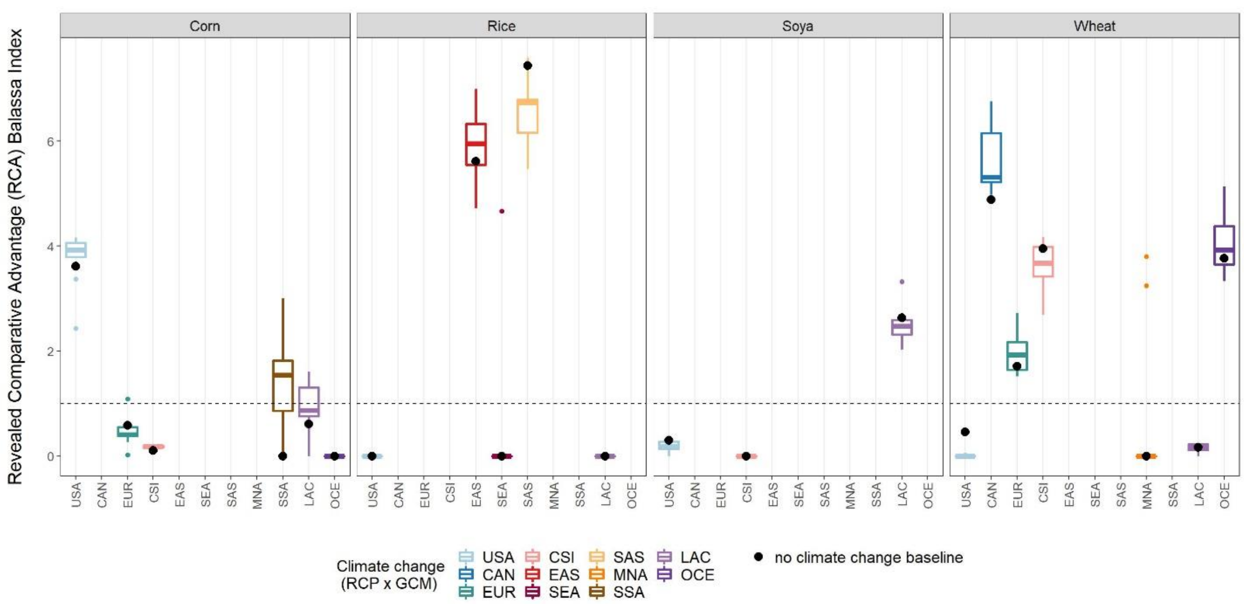
Supplementary Fig. 8 | Relative competitiveness (across regions) in response to climate change in 2050 under *Baseline trade*. The y axis indicates the producer price relative to the world average producer price for each crop, with values below zero indicating an above average competitiveness. Boxplots show the distribution of the relative producer price over the nine climate change scenarios (lower and upper hinges corresponding to 25th and 75th percentiles, whiskers reflecting values no further than 1.5*IQR from the hinges, and points showing outliers). Distinction is made between regions that have a deficit production in at least 90% of trade and climate change scenario (*Always deficit*), and regions that do not (*Not always deficit*).



Supplementary Fig. 9 | Relative competitiveness (across regions and crops) in response to climate change in 2050 under *Baseline trade*. The y-axis indicates for each crop and region the ratio of the crop price to the average price of all other crops. A ratio below 1 (below the dotted line) indicates a high competitiveness compared to other crops. Boxplots show the distribution of the ratio under the nine climate change scenarios (lower and upper hinges corresponding to 25th and 75th percentiles, whiskers reflecting values no further than 1.5*IQR from the hinge, and points outliers). Distinction is made between regions that have a deficit production in at least 90% of climate change and trade scenario (*Always deficit*), and regions who do not (*Not always deficit*).



Supplementary Fig. 10 | Relative yield of corn, rice, soya and wheat in response to climate change in 2050 under *Baseline trade*. The y-axis indicates for each crop the ratio of yield to the average yield of all other crops. A ratio larger than 1 (above the dotted line) indicates a low opportunity cost in terms of land. Boxplots show the distribution under the nine climate change scenarios (lower and upper hinges corresponding to 25th and 75th percentiles, whiskers reflecting values no further than 1.5*IQR from the hinge, and points outliers). Distinction is made between regions that have a deficit production in at least 90% of climate change and trade scenario (*Always deficit*), and regions who do not (*Not always deficit*).



Supplementary Fig. 11 | Impact of climate change on Revealed Comparative Advantage (RCA) Balassa Index in 2050 under *Facilitation + Tariff elimination*. The y-axis indicates for each crop the share of a region's exports in a region's total crop export relative to the share of the global exports in global total crop exports[14]. A value above one indicates a revealed comparative advantage. Boxplots show the distribution under the nine climate change scenarios (lower and upper hinges corresponding to 25th and 75th percentiles, whiskers reflecting values no further than 1.5*IQR from the hinge, and points outliers). Regions with deficit production in more than 10% of climate change and trade scenarios are excluded.

CO_2 fertilization sensitivity analysis

Model intercomparison studies show that the representation of the CO_2 fertilization effect is one of the key factors causing uncertainty in crop yield projections under climate change[15,16]. The fertilization effect depends on nutrient and water availability, and is heterogeneous across crops and regions[16–18]. Compared to other crop models, EPIC is on the conservative side in terms of the positive impact of CO_2 fertilization[15]. To check the sensitivity of our results to the impact of CO_2 fertilization on crop yields, we ran the full spectrum of RCP scenarios (RCP2.6, RCP4.5, RCP6, RCP8.5) with and without CO_2 fertilization. For the full spectrum, we have, however, only crop projections available from EPIC for four crops (corn, soya, wheat and rice) based on HadGEM2-ES climate change projections. The limited availability of non-CO_2 sensitivity runs is related to priorities set in the ISIMIP Fast Track protocol (see Method). To model climate change shifts for all crops in GLOBIOM, we map the crop yield impacts from the four crops to the other crops in a similar way as the mapping used by Müller and Robertson[19] for DSSAT (Supplementary Table 14).

Supplementary Table 14| Mapping of corn, wheat, rice and soya yield simulations from EPIC to all crops in GLOBIOM for the CO_2 sensitivity analysis (RCP2.6 – RCP8.5: with or without CO_2 fertilization)[1].

GLOBIOM crop	Mapping
C_3 crops (cassava, groundnuts, rapeseed, sunflower, palm, chickpeas, cotton, potatoes, sweet potatoes, beans)	C_3 crops are represented by the average climate impact on the three C_3 crops that are directly simulated (wheat, rice and soybean)[2]
Corn	Corn yield is directly simulated
Millet, sorghum	Millet and sorghum are represented by modified corn yield simulations: only half of the negative effects are applied due to better drought tolerance
Rice	Rice yield is directly simulated
Soybean	Soybean yield is directly simulated
Sugarcane	Sugarcane yield is represented by corn yield simulations
Wheat	Wheat yield is directly simulated
Other grains (barley)	Barley is represented by modified wheat yield simulations: only half of the negative effects are applied due to better drought tolerance

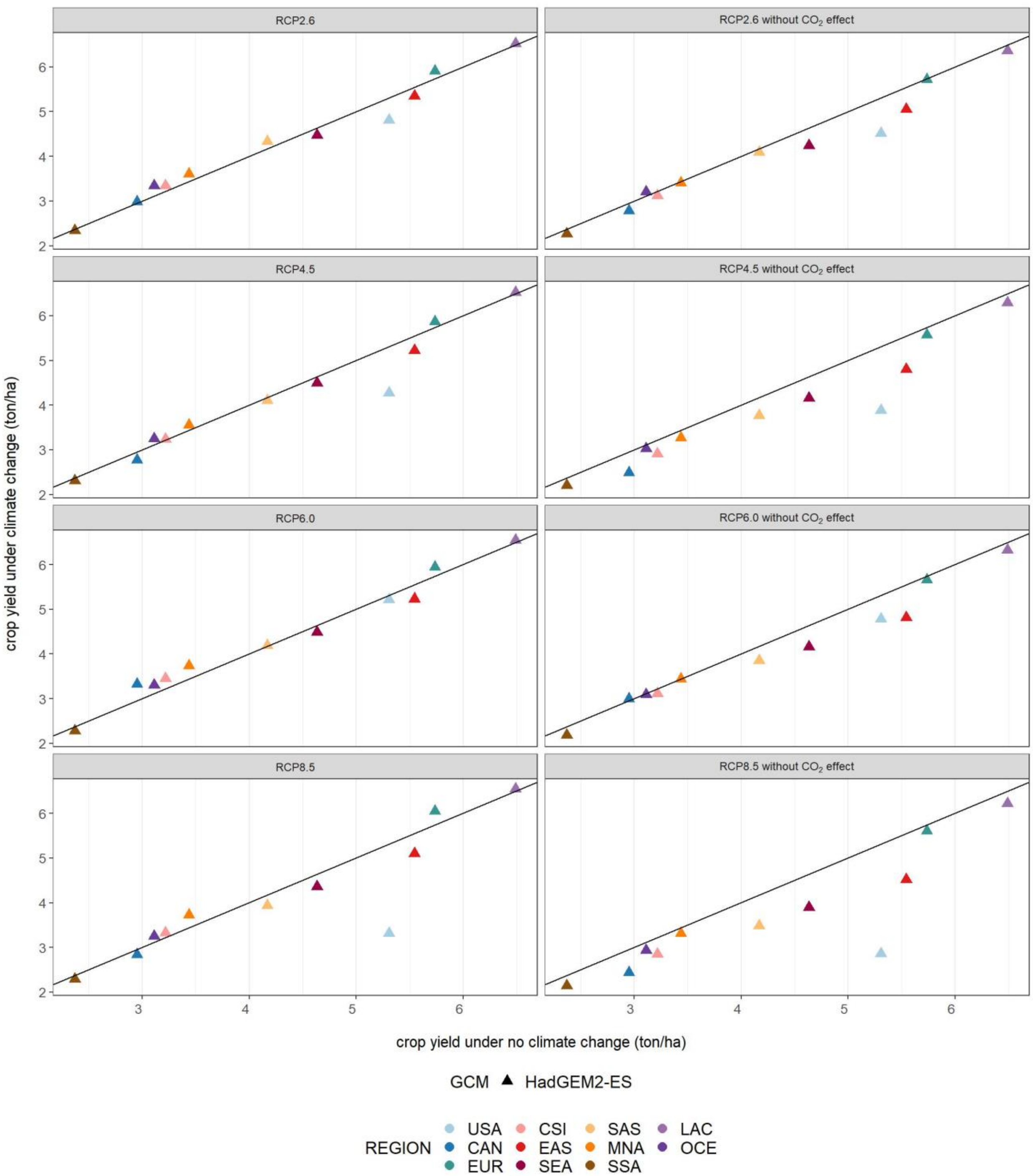
[1]The sensitivity analysis to CO_2 fertilization is limited to crop impacts. For grassland, we use the EPIC yield shifters for each RCP including CO_2 fertilization. [2]We compute the average of wheat, rice and soybean impacts weighted by base year area x yield.

Supplementary Fig. 12 shows the average crop yield impacts under the different RCPs, with and without the effect of CO_2 fertilization. The simulated crop yield under each RCP is lower when CO_2 fertilization is not taken into account. Average crop yields in this scenario set are in most regions larger than the simulations in the paper (Supplementary Table 15). This is a consequence of the bias that is introduced by mapping the impacts of corn, wheat, soya and rice to the other crops compared to the scenario set in the paper where we use direct simulations from EPIC for all crops.

Supplementary Fig. 13 plots the global risk of hunger under the alternative set of climate change scenarios. In the *Baseline trade* scenario, the risk of hunger is always higher without than with CO_2 fertilization. The hunger projections under the scenarios that we miss in the main scenario set (RCP2.6 – RCP6 without CO_2) lie between the lowest (RCP2.6 with CO_2) and highest climate change impact (RCP8.5 without CO_2). This shows that we capture the full range of climate change impacts in our main scenario set. Note that the increase in risk of hunger under these climate change scenarios is lower than in the original runs (Fig. 1 in main text). This is related to the bias introduced by the mapping, as also reflected in the lower average crop yield impacts in the simulations based on the 4 priority crops (Supplementary Table 15). As in the original run, the risk of hunger in RCP4.5 is slightly higher than in RCP6. In 2050 the atmospheric concentration of CO_2 and likely range of global mean temperature increase are slightly higher under RCP4.5 than under RCP6, while by the end of the century the situation is reversed[20,21]. The effect of the trade scenarios is the same as in the original run: *Fixed imports* and *pre-Doha tariffs* increase hunger, while *Tariff elimination*, *Facilitation* and the combined scenario decrease hunger. Also the regional results from the main scenario set (Extended Data Fig. 7) are robust under the alternative set of climate change scenarios (Supplementary Fig. 14). SAS and SSA face the most severe hunger risks. SSA, EAS and MNA benefit the most from trade liberalization and facilitation in terms of hunger reduction, while in SEA and SAS tariff elimination has adverse impacts in some climate change scenarios.

We also analyze the relation between hunger, trade costs and crop yields based on the alternative set of climate change scenarios (Supplementary Table 16). The findings are similar to the results in main text (Table 1): reducing trade costs lowers the risk of hunger and lower crop yields increases the risk of hunger. When excluding regions that experience negative impacts in some trade scenarios (SAS, SEA), we find, however, no significant negative interaction effect. This could be related to the overall lower hunger impacts of the alternative climate change scenario set.

Lastly, to assess the sensitivity of our comparative advantage results to CO_2 fertilization, we cannot use the alternative set of climate change scenarios because comparative advantage is determined by relative crop yield impacts. The mapping used to extrapolate impacts from the 4 crops to other crops implies that crop impacts are by construction correlated and that an analysis of comparative advantage based on these simulations would thus be biased. We therefore use our original scenario set and compare our indicator of comparative advantage between RCP8.5 with and without CO_2 fertilization. Supplementary Fig. 15 illustrates that the changes in share of global production for each crop are similar in the RCP8.5 scenario with and without CO_2 fertilization. This suggests that the conclusion on the impact of climate change on the pattern of comparative advantage is not affected by the CO_2 fertilization effect.

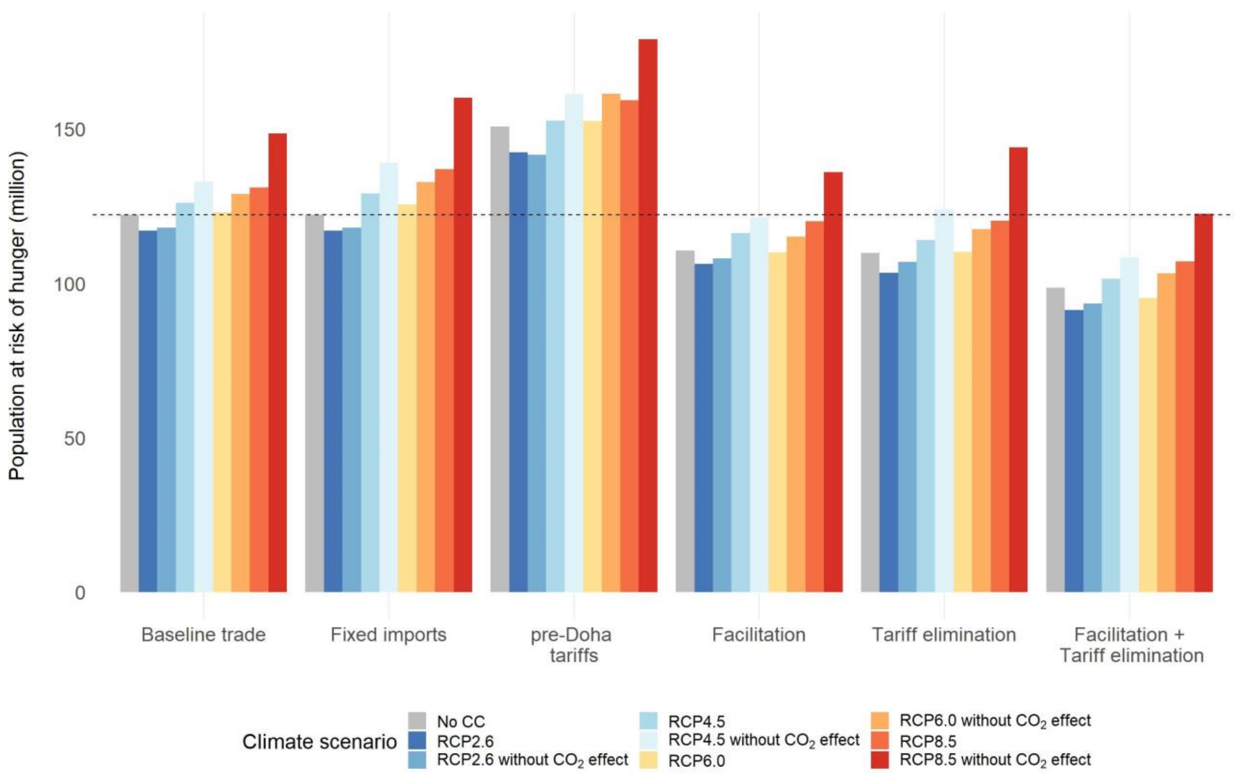


Supplementary Fig. 12 | Biophysical impact of climate change on average crop yield in each region by 2050 as projected by the EPIC crop model. Yields in ton dry matter per ha. The x-axis indicates the average crop yield under no climate change and y-axis the average crop yield under climate change for different RCPs with and without considering the CO_2 fertilization effect. Points above the black line indicate an increase in crop yield, points below a decrease in crop yield. Direct simulations for corn, wheat, rice and soya. Climate change impacts for the other crops are based on the mappings in Supplementary Table 14.

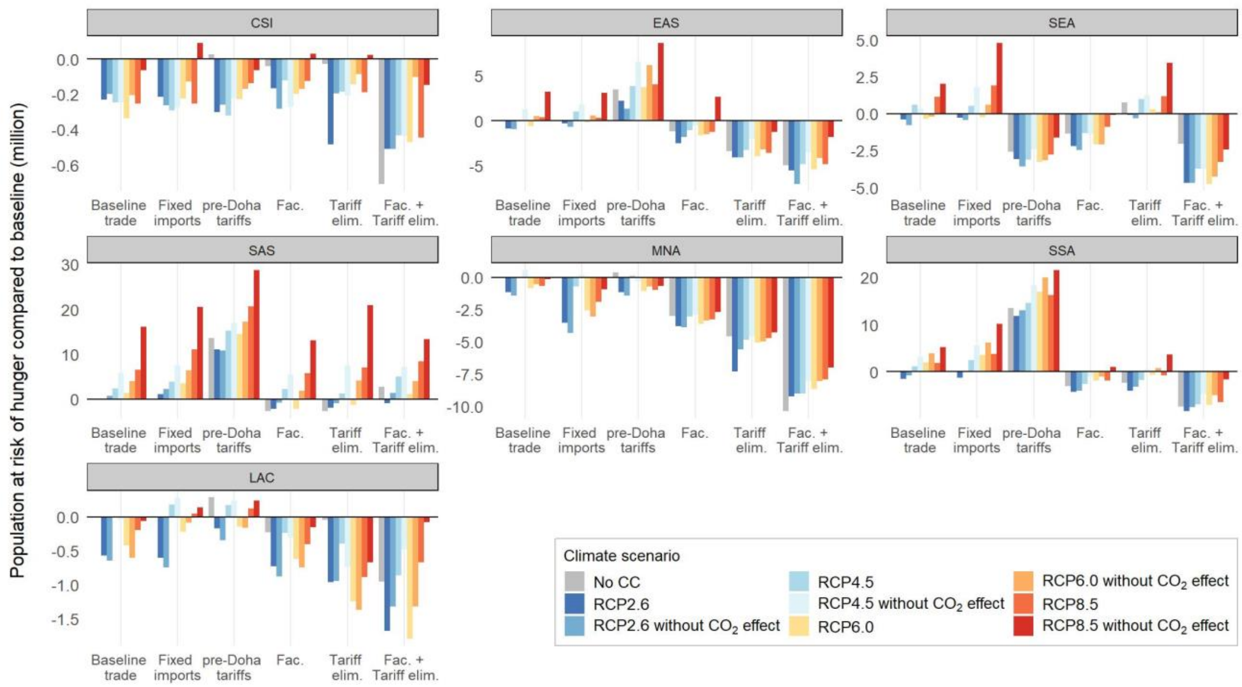
Supplementary Table 15 | Comparison of average crop yield (dm ton/ha) in each region based on direct EPIC simulations on all crops (1) and EPIC simulations based on 4 major crops (2), with (wt) and without (wo) the effect of CO_2 fertilization**.** Climate projections from HadGEM2-ES.

	CAN		CSI		EAS		EUR		LAC		MNA	
Climate scenario	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(2)	(1)	(1)	(2)
RCP2.6 wt CO_2	2.93	2.98	3.29	3.34	5.34	5.35	5.92	5.91	6.20	6.52	3.48	3.61
RCP4.5 wt CO_2	2.71	2.77	3.24	3.24	5.20	5.23	5.88	5.86	6.12	6.52	3.42	3.56
RCP6.0 wt CO_2	3.32	3.33	3.42	3.46	5.20	5.23	6.01	5.94	6.20	6.55	3.60	3.74
RCP8.5 wt CO_2	2.80	2.84	3.29	3.33	5.06	5.10	6.09	6.05	6.02	6.55	3.56	3.73
RCP8.5 wo CO_2	2.35	2.44	2.75	2.85	4.51	4.52	5.46	5.61	5.64	6.22	3.12	3.32

	OCE		SAS		SEA		SSA		USA	
Climate scenario	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
RCP2.6 wt CO_2	3.26	3.35	4.22	4.33	4.28	4.47	2.26	2.34	4.81	4.81
RCP4.5 wt CO_2	3.15	3.25	3.90	4.11	4.28	4.50	2.19	2.31	4.28	4.27
RCP6.0 wt CO_2	3.23	3.30	4.01	4.19	4.28	4.49	2.18	2.28	5.22	5.21
RCP8.5 wt CO_2	3.13	3.26	3.68	3.94	4.08	4.36	2.15	2.29	3.31	3.31
RCP8.5 wo CO_2	2.73	2.93	3.27	3.48	3.61	3.89	2.02	2.15	2.85	2.86



Supplementary Fig. 13 | Global population at risk of hunger (million) in 2050 across RCPs from HadGEM2-ES and trade scenarios – impact of CO_2 fertilization.

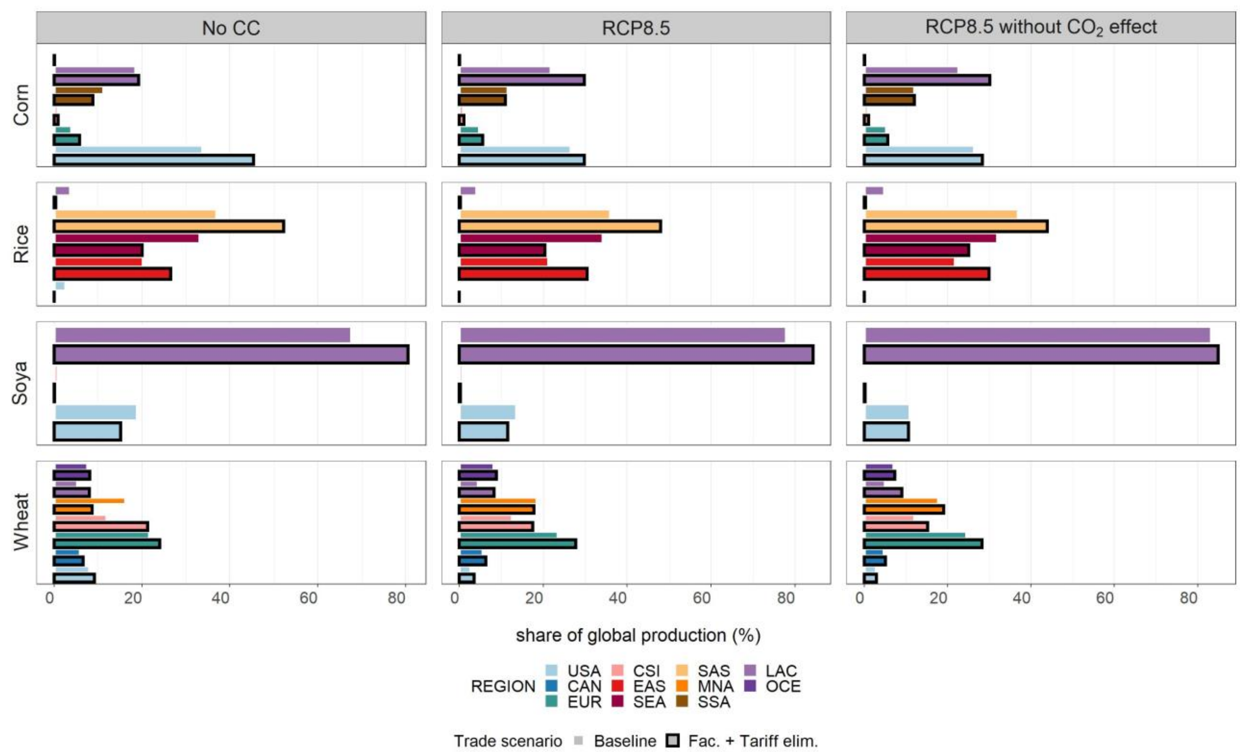


Supplementary Fig. 14 | Population at risk of hunger (million) in 2050 across RCPs from HadGEM2-ES and trade scenarios in hunger-affected regions – impact of CO_2 fertilization.

Supplementary Table 16 | Results from OLS estimation of the impact of crop yields, trade costs and their interaction on population at risk of hunger and food availability. Observations are GLOBIOM output for the 11 world regions under five different trade scenarios (Baseline, pre-Doha tariffs, Facilitation, Tariff elimination, and Facilitation + Tariff elimination) and the set of 9 alternative climate change scenarios in 2050 (No CC, RCP2.6 – RCP8.5: with and without CO_2 fertilization effect projected by EPIC & HadGEM2-ES).

	Population at risk of hunger (million)		Food availability (kcal/cap/day)	
	(1) All regions	(2) without SAS and SEA	(1) All regions	(2) without SAS and SEA
Crop yield (% change)	-8.35 ***	-2.85	241.00 ***	210.00 ***
	(2.99)	(2.22)	(39.30)	(43.40)
Trade cost (log of US$/$10^6$ kcal)	4.22 ***	4.62 ***	-42.90 ***	-63.90 ***
	(0.53)	(0.60)	(6.56)	(9.68)
Crop yield x Trade cost	0.01	-5.65	215.00 ***	271.00 ***
	(5.32)	(4.17)	(74.00)	(85.60)

Significance levels: *p<0.1; **p<0.05; ***p<0.01. Regional fixed effects included. Heteroskedastic robust standard errors in brackets. N = 495 for (1) and 405 for (2). Adjusted R squared is 0.926 (1) and 0.948 (2) for hunger regressions and 0.955 (1) and 0.920 (2) for food availability regressions.



Supplementary Fig. 15 | Impact of trade liberalization and trade facilitation on regions' share of global production of corn, rice, soya and wheat under no climate change (No CC), RCP8.5 with CO_2 fertilization and RCP8.5 without CO_2 fertilization. Direct EPIC simulations on all crops based on climate change projections from HadGEM2-ES.

Supplementary References

1. Bouët, A., Decreux, Y., Fontagné, L., Jean, S. & Laborde, D. Assessing applied protection across the world. *Rev. Int. Econ.* **16**, 850–863 (2008).
2. Guimbard, H., Jean, S., Mimouni, M. & Pichot, X. *MAcMap-HS6 2007, an exhaustive and consistent measure of applied protection in 2007*. (2012).
3. Wiebe, K. *et al.* Climate change impacts on agriculture in 2050 under a range of plausible socioeconomic and emissions scenarios. *Environ. Res. Lett.* **10**, (2015).
4. Baldos, U. L. C. & Hertel, T. W. The role of international trade in managing food security risks from climate change. *Food Secur.* **7**, 275–290 (2015).
5. Randhir, T. O. & Thomas, W. Trade Liberalization as a Vehicle for Adapting to Global Warming. *Agric. Resour. Econ. Rev.* **29**, 159–172 (2000).
6. Costinot, A., Donaldson, D. & Smith, C. Evolving Comparative Advantage and the Impact of Climate Change in Agricultural Markets: Evidence from 1.7 Million Fields around the World. *J. Polit. Econ.* **124**, 205–248 (2016).
7. Stevanović, M. *et al.* The impact of high-end climate change on agricultural welfare. *Sci. Adv.* 1–10 (2016).
8. Gouel, C. & Laborde, D. *The Crucial Role of International Trade in Adaptation to Climate Change*. (2018).
9. Cui, H. D., Kuiper, M., van Meijl, H. & Tabeau, A. *Climate change and global market integration: Implications for global economic activities, agricultural commodities, and food security. The State of Agricultural Commodity Markets (SOCO) 2018: Background paper*. (FAO, 2018).
10. Krugman, P. & Obstfeld, M. *International Economics Theory and Policy*. (1997).
11. Costinot, A., Donaldson, D. & Komunjer, I. What goods do countries trade? A quantitative exploration of Ricardo's ideas. *Rev. Econ. Stud.* **79**, 581–608 (2012).
12. Deardorff, A. V. Testing Trade Theories and Predicting Trade Flows. in *Handbook of International Economics, Volume 1* (eds. Jones, R. W. & Kenen, P.) 467–517 (1984).
13. Costinot, A. & Donaldson, D. Ricardo's Theory of Comparative Advantage: Old Idea, New Evidence. *Am. Econ. Rev. Pap. Proc.* **102**, 453–458 (2012).
14. Balassa, B. *Trade Liberalisation and Revealed Comparative Advantage*. (1965).
15. Rosenzweig, C. *et al.* Assessing agricultural risks of climate change in the 21st century in a global gridded crop model intercomparison. *Proc. Natl. Acad. Sci.* **111**, 3268–3273 (2014).

16. Moore, F. C., Baldos, U. L. C. & Hertel, T. Economic impacts of climate change on agriculture : a comparison of process-based and statistical yield models. *Environ. Res. Lett.* (2017).

17. McGrath, J. M. & Lobell, D. B. Regional disparities in the CO2 fertilization effect and implications for crop yields. *Environ. Res. Lett.* **8**, (2013).

18. Terrer, C. *et al.* Nitrogen and phosphorus constrain the CO2 fertilization of global plant biomass. *Nat. Clim. Chang.* **9**, 684–689 (2019).

19. Müller, C. & Robertson, R. Projecting future crop productivity for global economic modeling. *Agric. Econ.* **45**, 37–50 (2014).

20. IPCC. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. (Cambridge University Press, 2013).

21. Moss, R. H. *et al.* The next generation of scenarios for climate change research and assessment. *Nature* **463**, 747–756 (2010).